

Autonomous Soaring 2005 Flight Data Summary

Flight testing of the 14ft span CloudSwift UAV was conducted during the summer of 2005. Test maneuvers included aircraft checkout, Piccolo gain tuning, FTS range tests, and thermal soaring research flights. A description of each flight is given in table 1.

| Flight # | Date | SW Version | Purpose | General Notes |
|----------|---------|------------|---------------------|---|
| 1 | 7/25/05 | 1.2.2 | Aircraft checkout | |
| 2 | 7/25/05 | 1.2.2 | Piccolo gain tuning | |
| 3 | 8/1/05 | 1.2.2 | Piccolo gain tuning | |
| 4 | 8/1/05 | 1.2.2 | Piccolo gain tuning | |
| 5 | 8/1/05 | 1.2.2 | Piccolo gain tuning | |
| 6 | 8/5/05 | as6_40 | Research flight | Soaring never engaged |
| 7 | 8/12/05 | as6_41 | Research flight | Triggered on small thermals |
| 8 | 8/12/05 | as6_42 | Research flight | 1 st successful autonomous soaring |
| 9 | 8/30/05 | as6_42 | Pdyn gain tuning | Tuned speed controller |
| 10 | 9/7/05 | as6_49 | Research flight | Piloted soaring in this flight |
| 11 | 9/7/05 | as6_49 | Research flight | 9 thermals found |
| 12 | 9/7/05 | as6_49 | Research flight | Largest climb in single thermal |
| 13 | 9/15/06 | as6_51 | FTS test flight | Pilot checkout flight |
| 14 | 9/15/06 | as6_51 | FTS test flight | Surface sweeps performed |
| 15 | 9/15/06 | as6_51 | Research flight | 3 thermals found |
| 16 | 9/15/06 | as6_51 | Research flight | 1 thermal found |
| 17 | 9/15/06 | as6_51 | Research flight | 6 thermals found |

Nomenclature

| | |
|------------|---|
| Ail | aileron deflection, left – right, positive for right roll. |
| Alt | altitude. |
| Alt_cmd | altitude command |
| AP_Global | autopilot on/off state. 0=piloted mode, 1=autopilot on. |
| boxTemp | temperature inside Piccolo box |
| CPU | central processing unit |
| Edot | rate of change of total energy. “True” refers to a forward/backward filtered value of total energy rate and does not include engine effect or aircraft sink rate cancellation. “Autosoar” refers to the value used by the onboard system. |
| Ele | elevator, positive trailing edge down. |
| Input | Piccolo power input voltage |
| InputC_A | Piccolo power input current |
| Rud | Rudder, positive trailing edge right. |
| TAS | true airspeed, |
| Vel | aircraft velocity. |
| X Position | position in the North/South direction, positive X is North. |
| Y Position | position in the East/West direction, positive Y is East. |

Contents

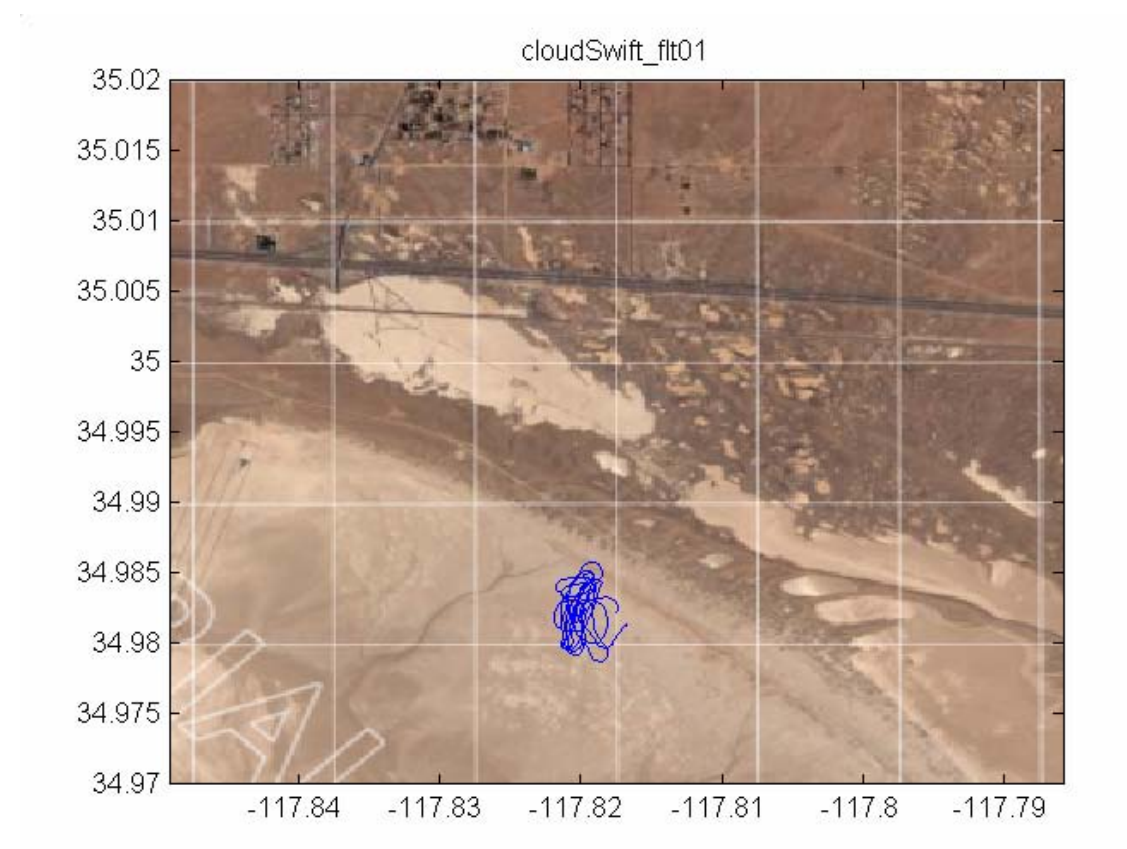
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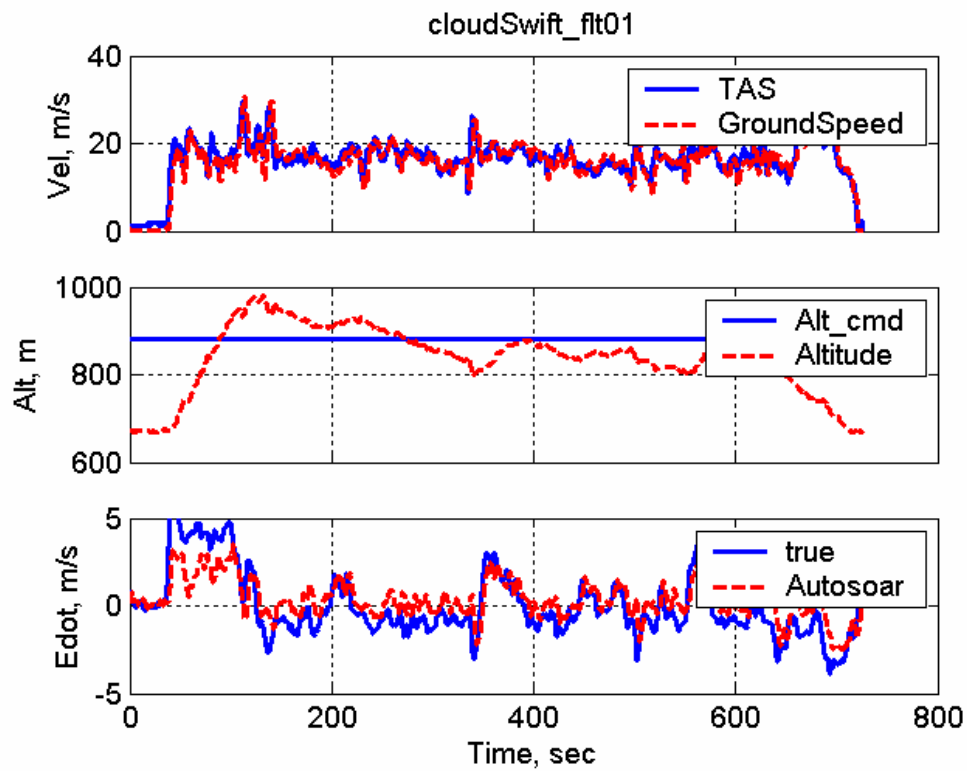
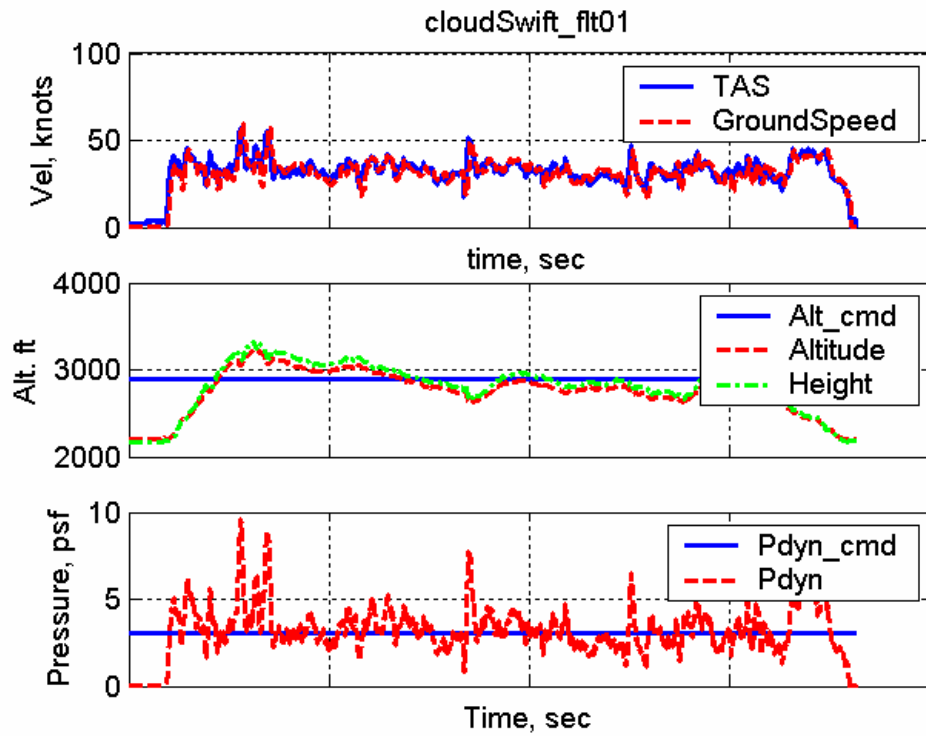
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Flight 1

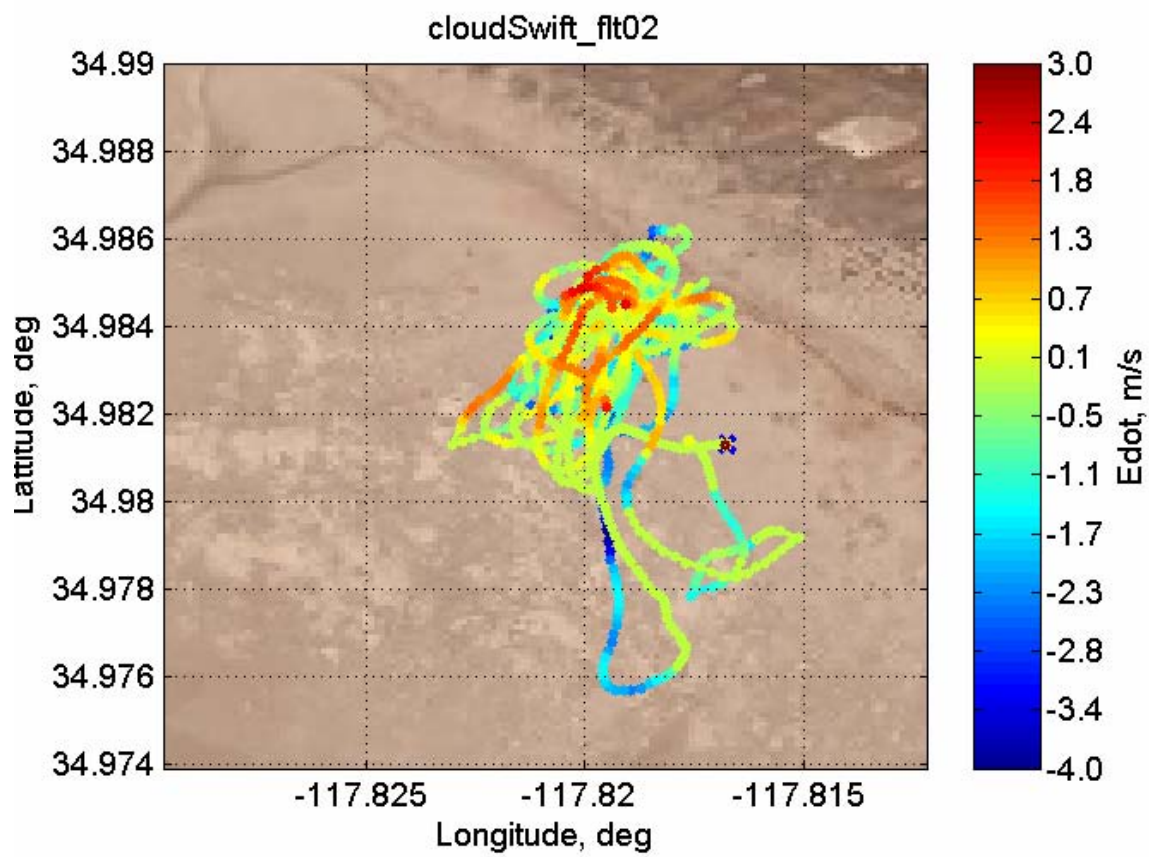
Flight 1 was used to perform basic envelope expansion of the aircraft systems. Battery voltage, communications signal strength, and link status was monitored closely during the flight. Surface double-type maneuvers were used to discern stability and control of the airframe. A throttle doublet was performed to provide data for engine model tuning in the soaring algorithms.

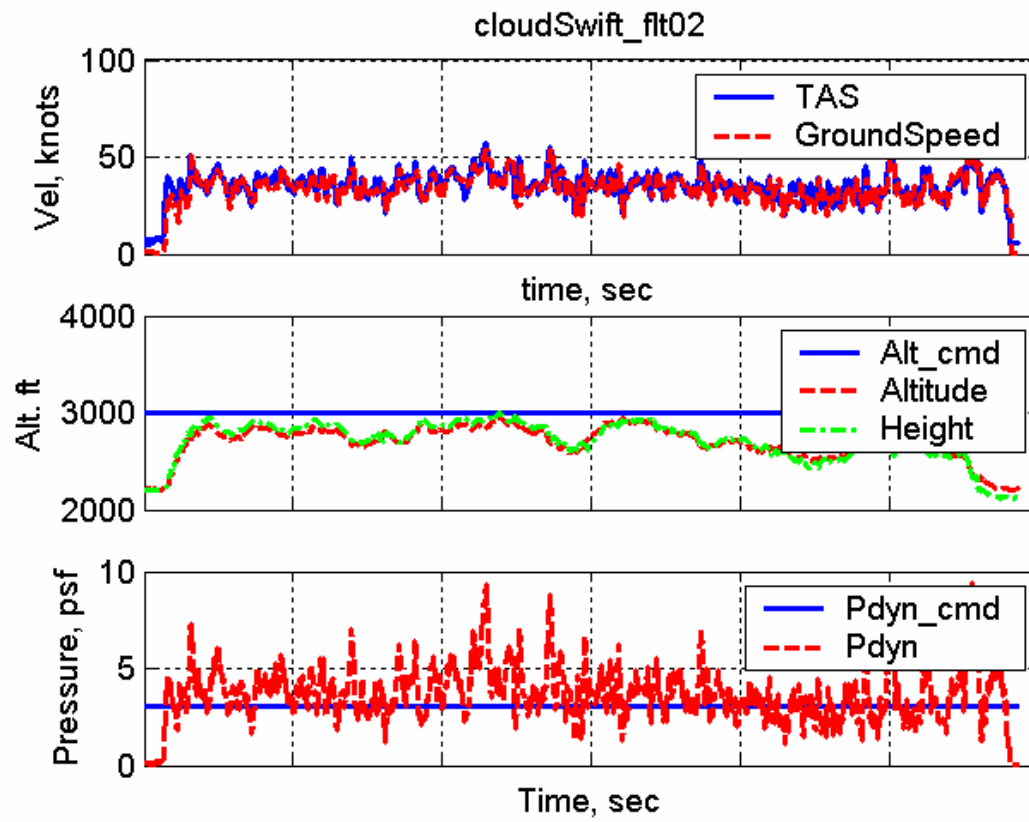




Flight 2

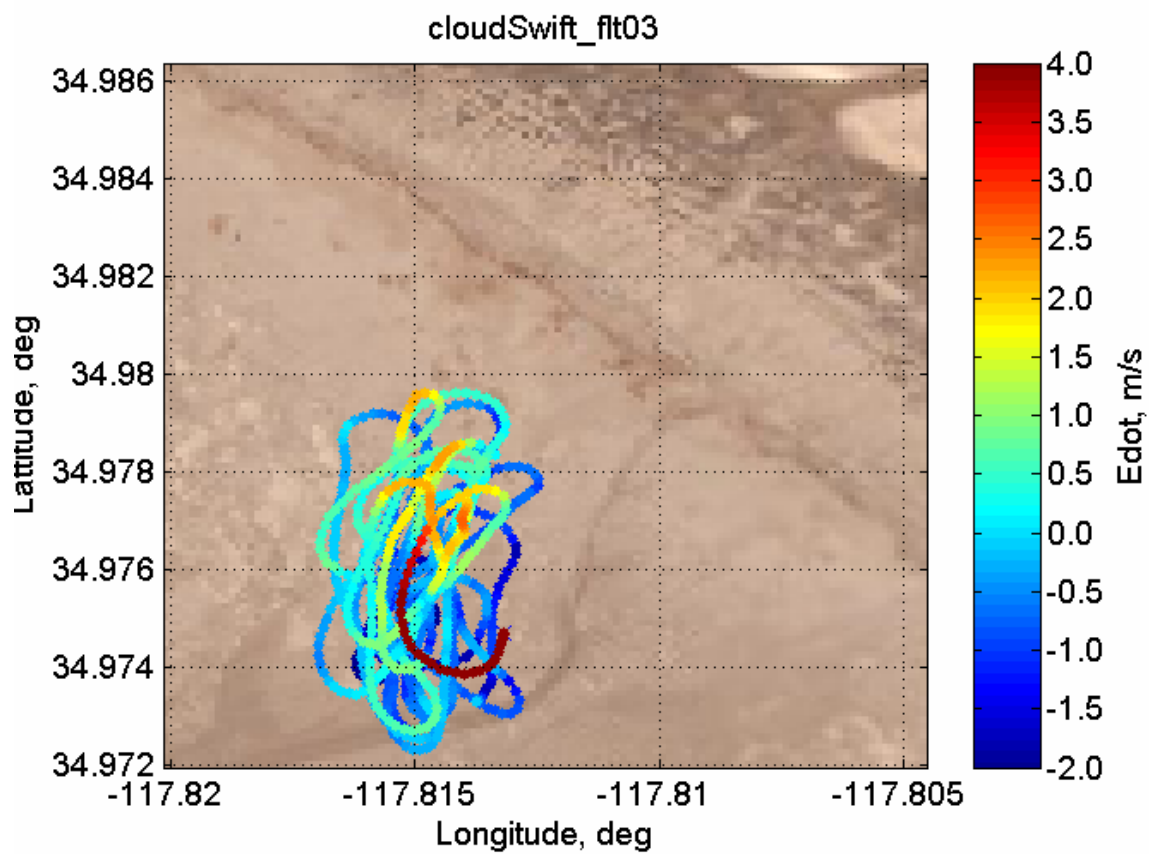
Flight 2 was used to tune the autopilot gains.

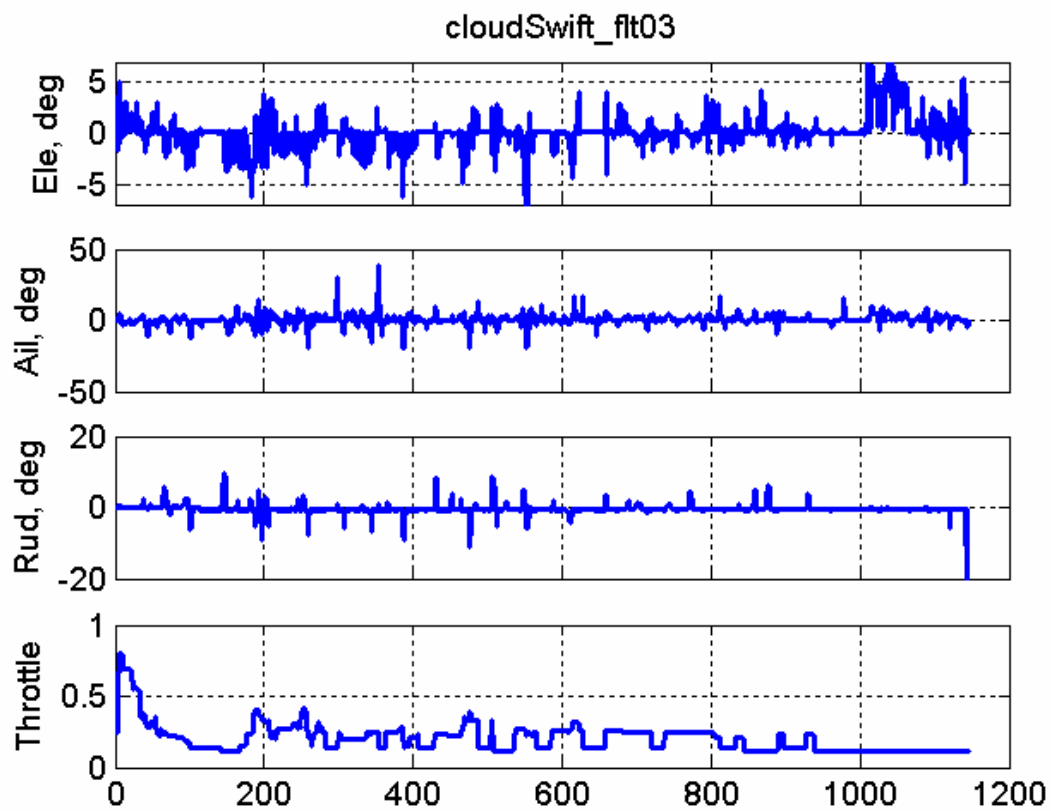
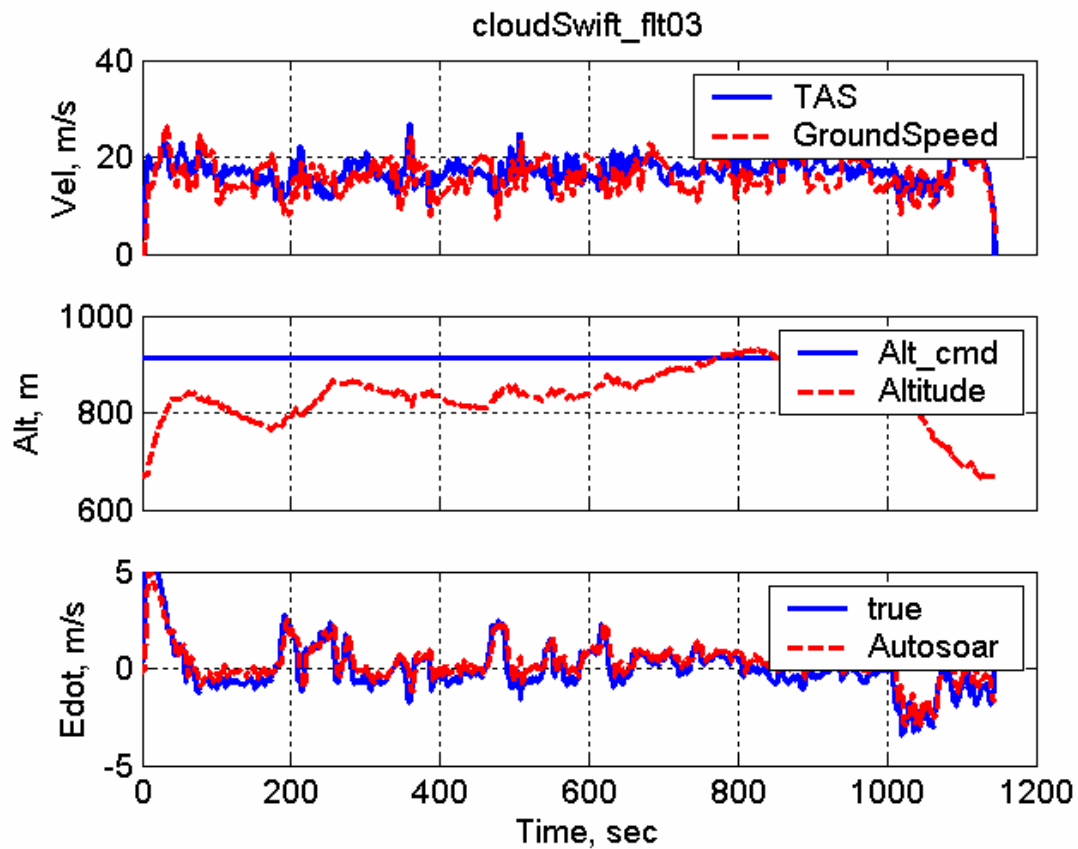


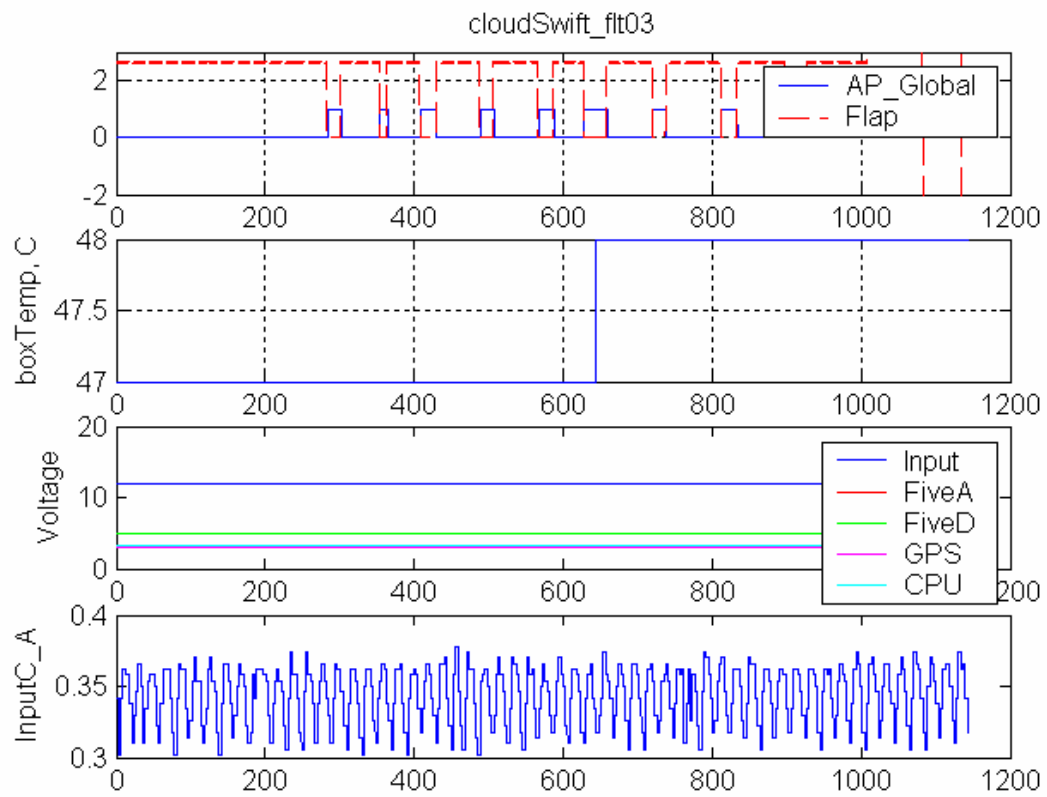


Flight 3

Flight 3 was used to tune the autopilot gains. Airspeed gains were tuned and tested.

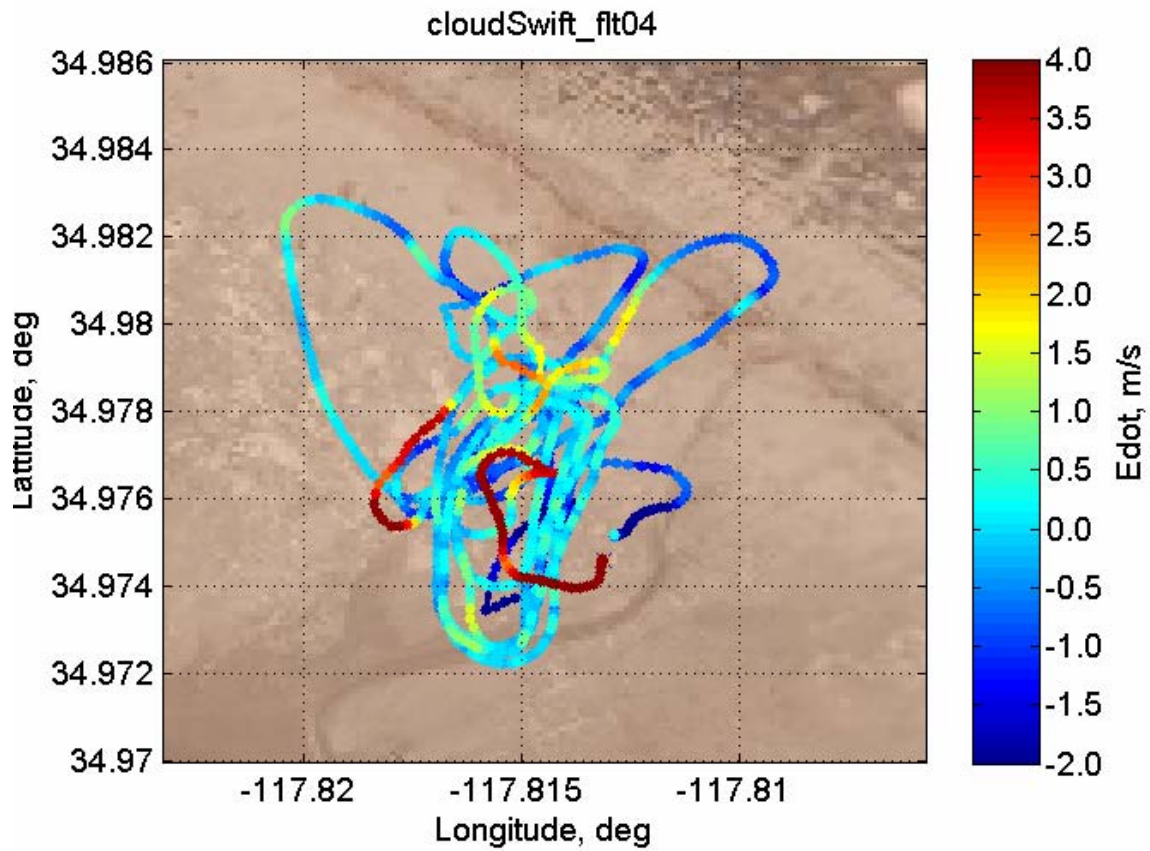


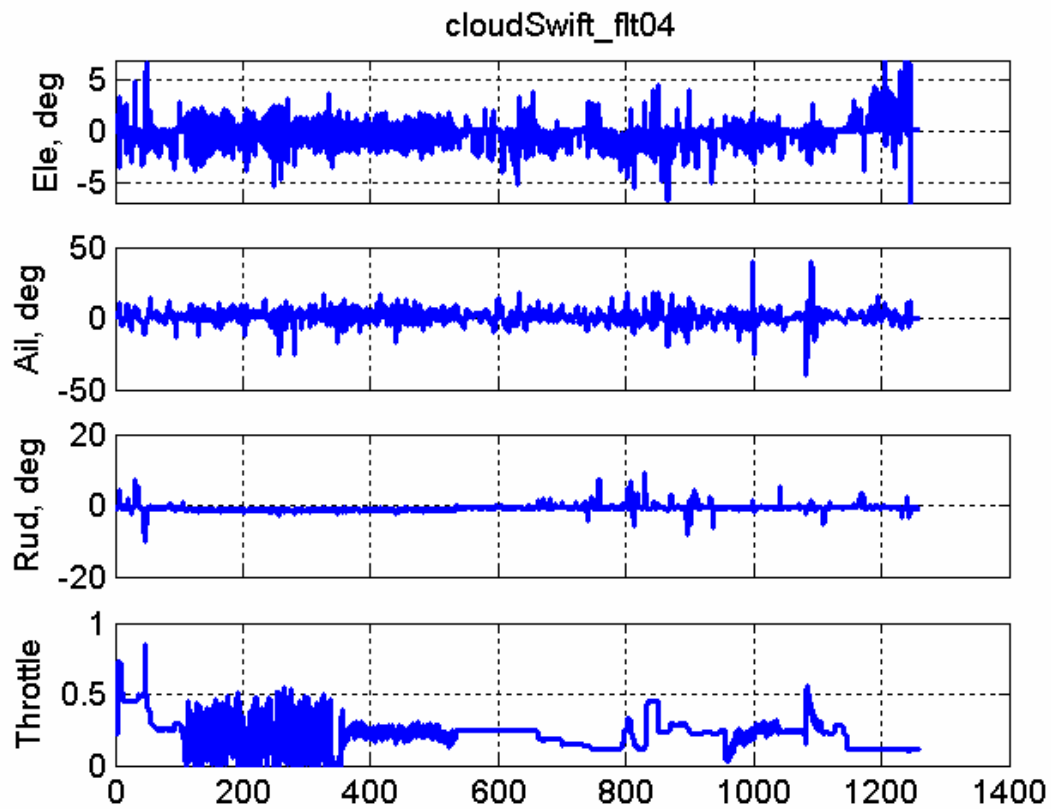
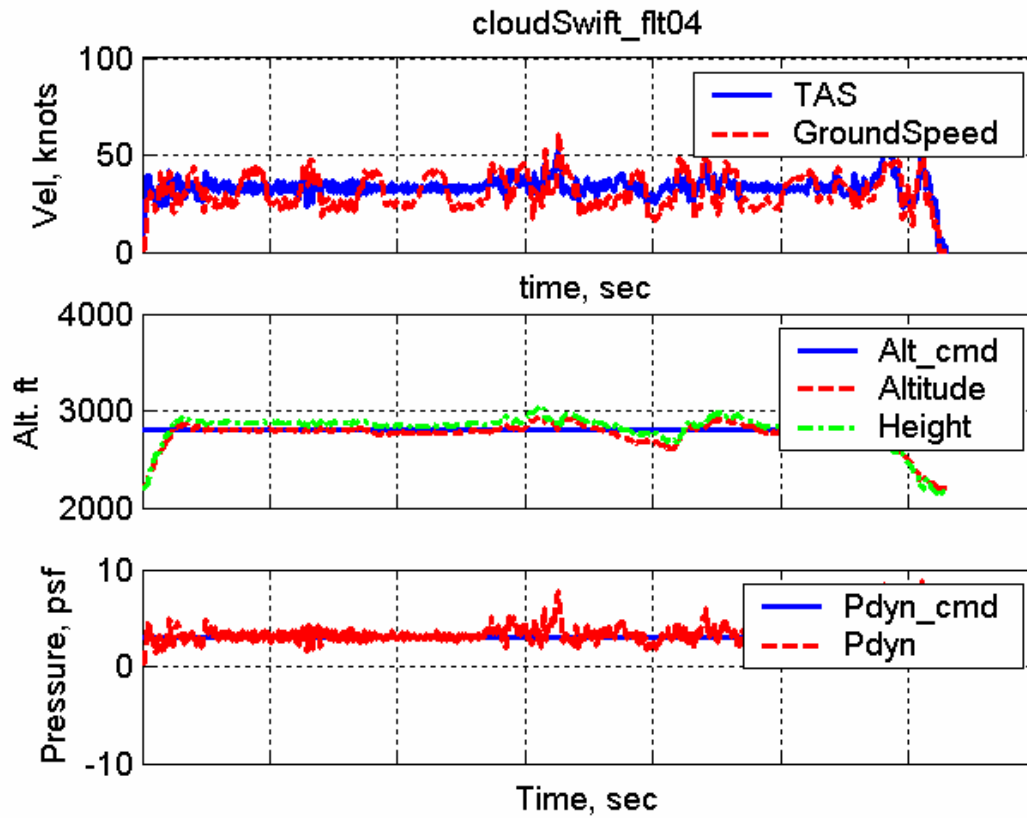


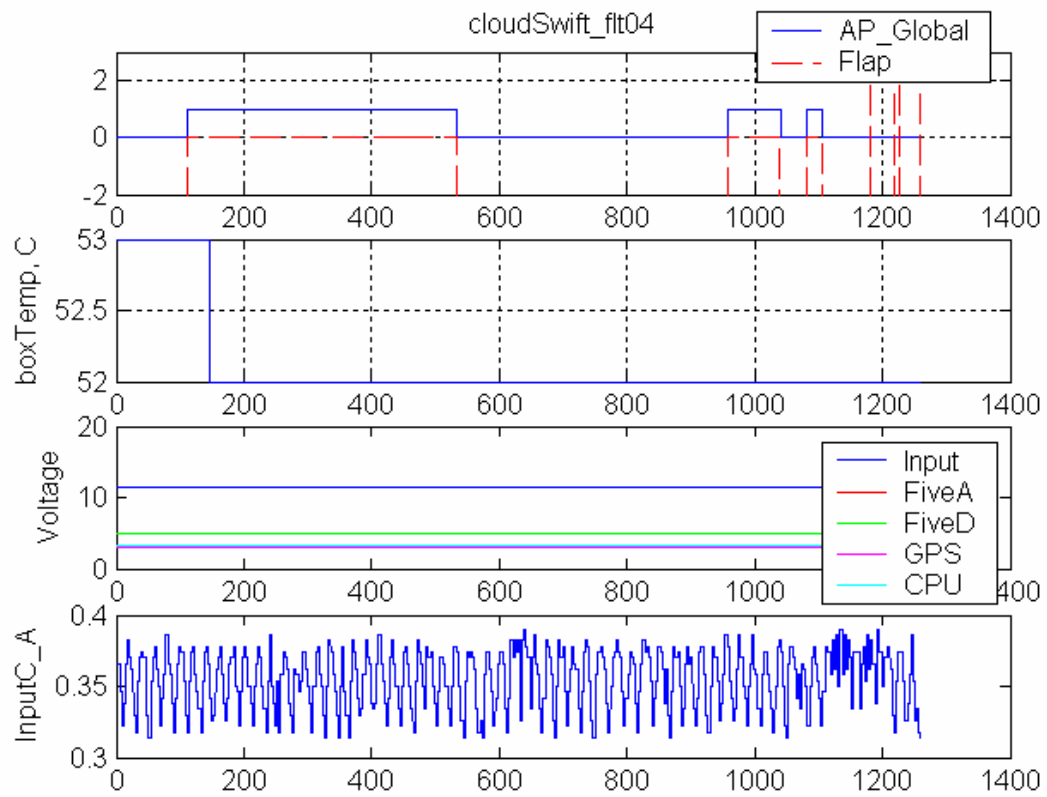


Flight 4

Flight 4 was used to tune the autopilot gains. Altitude and airspeed gains were tuned during this flight.

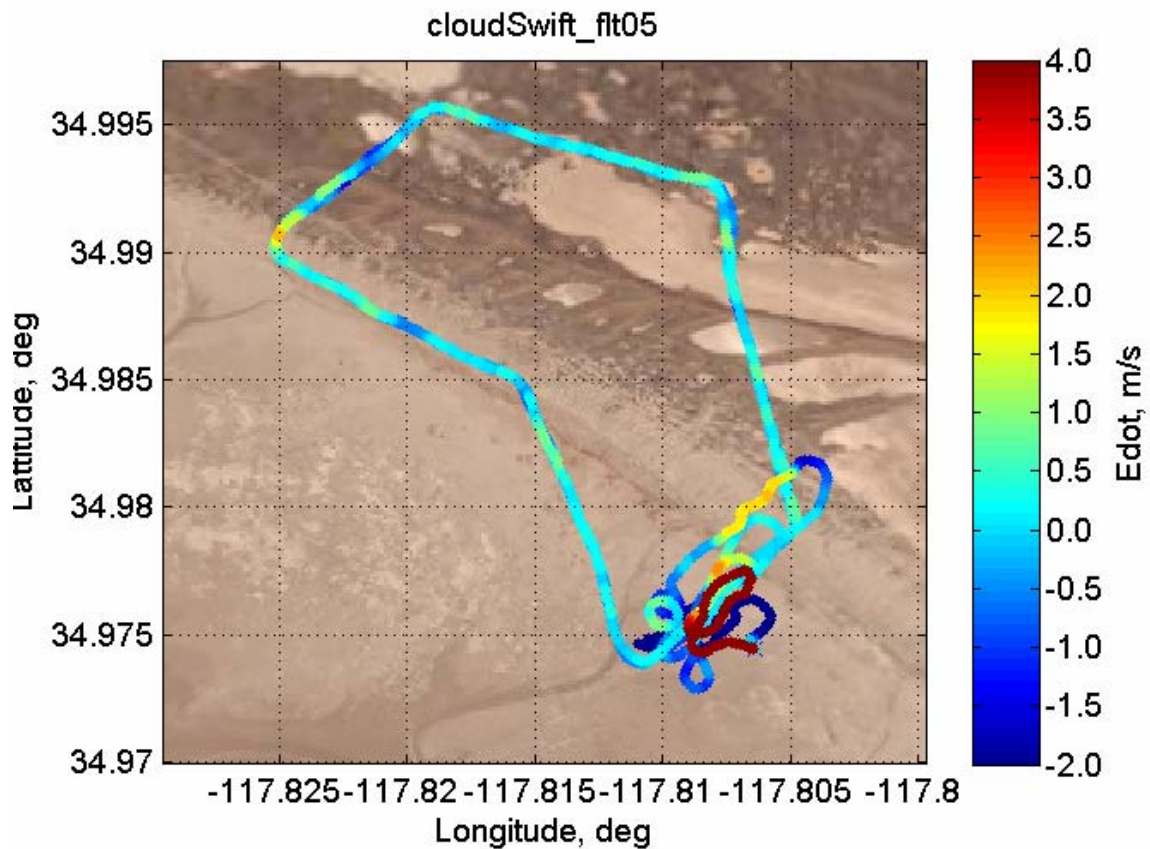


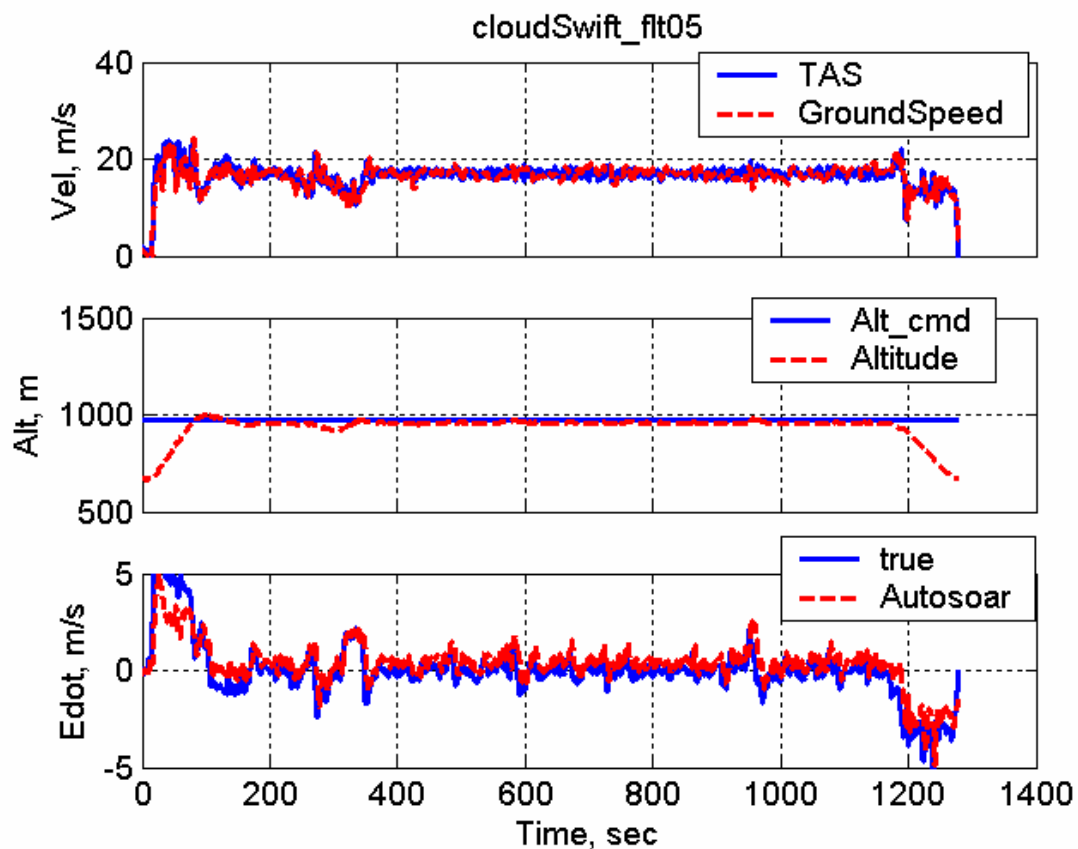
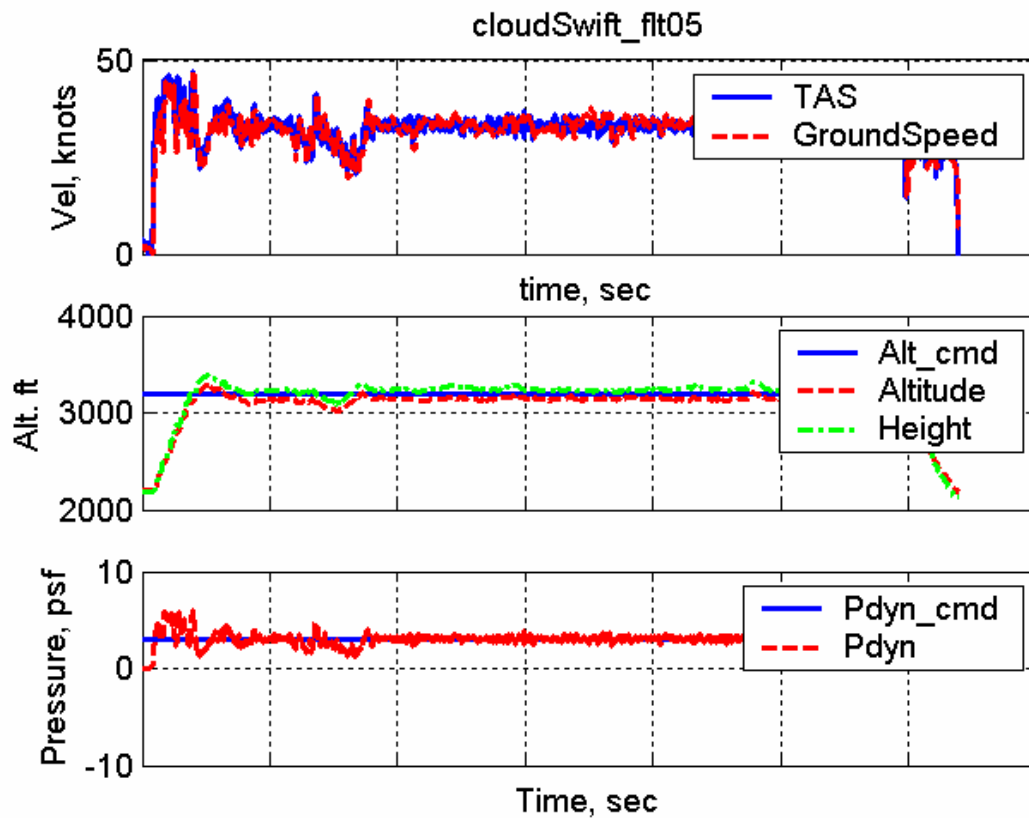


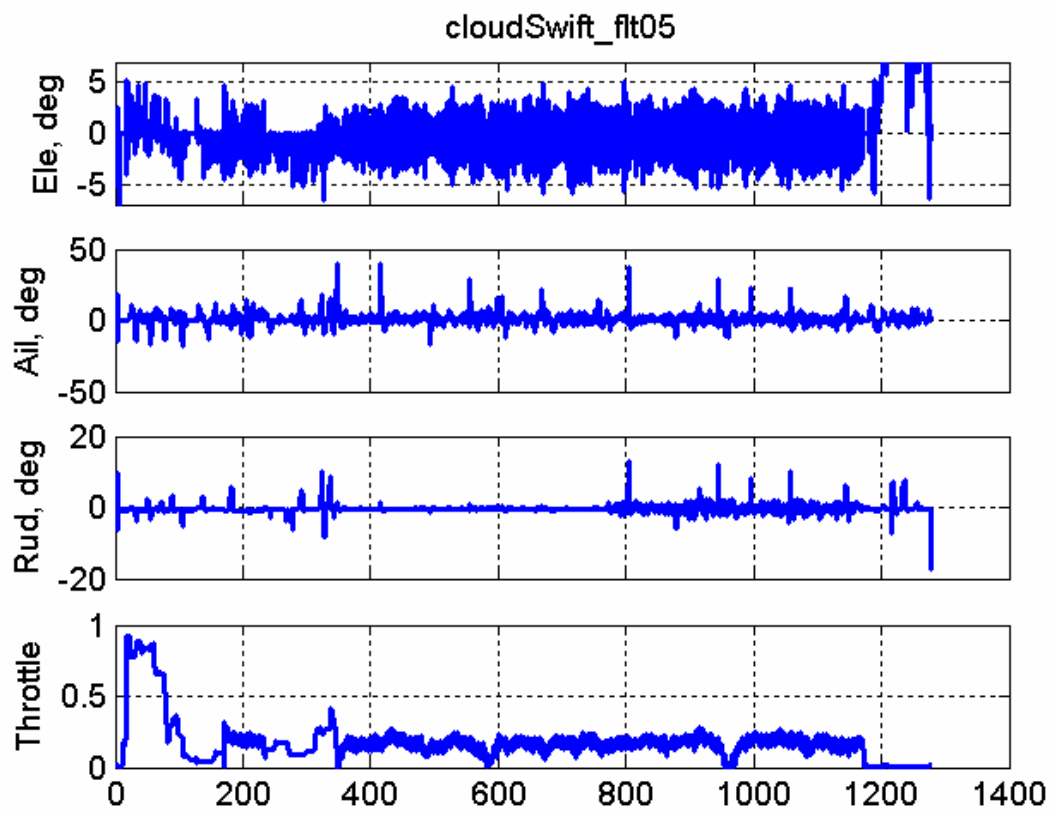
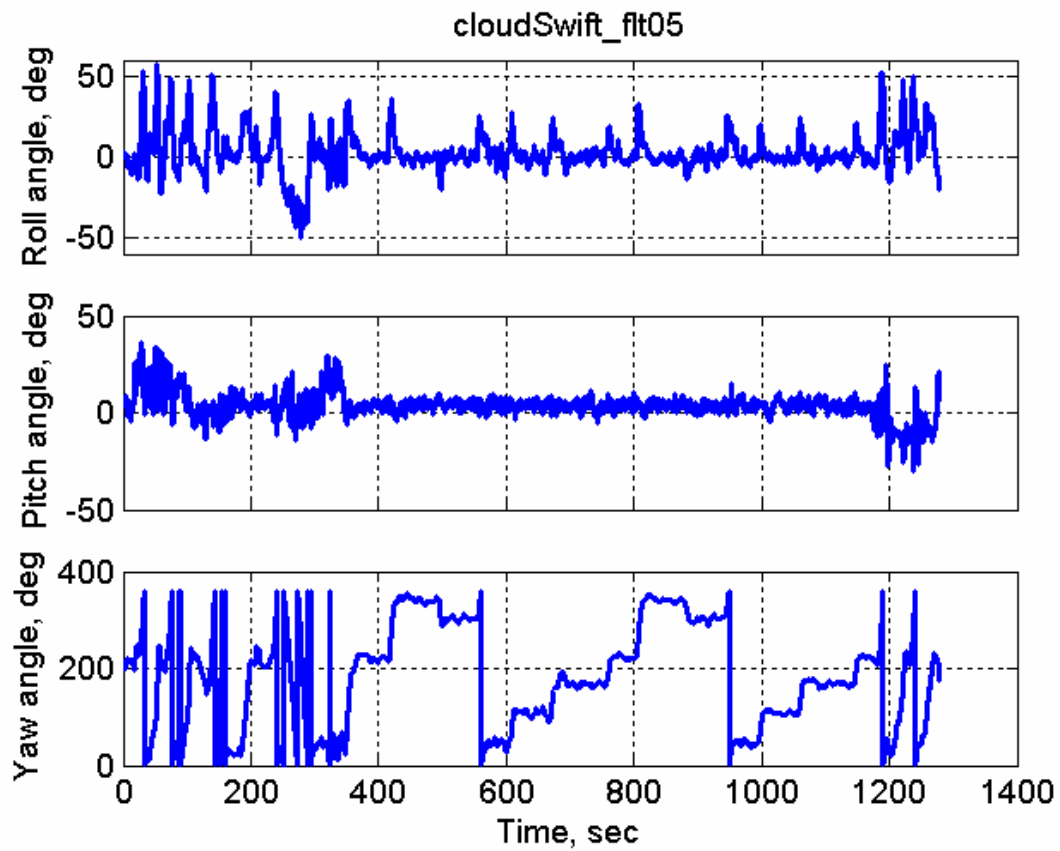


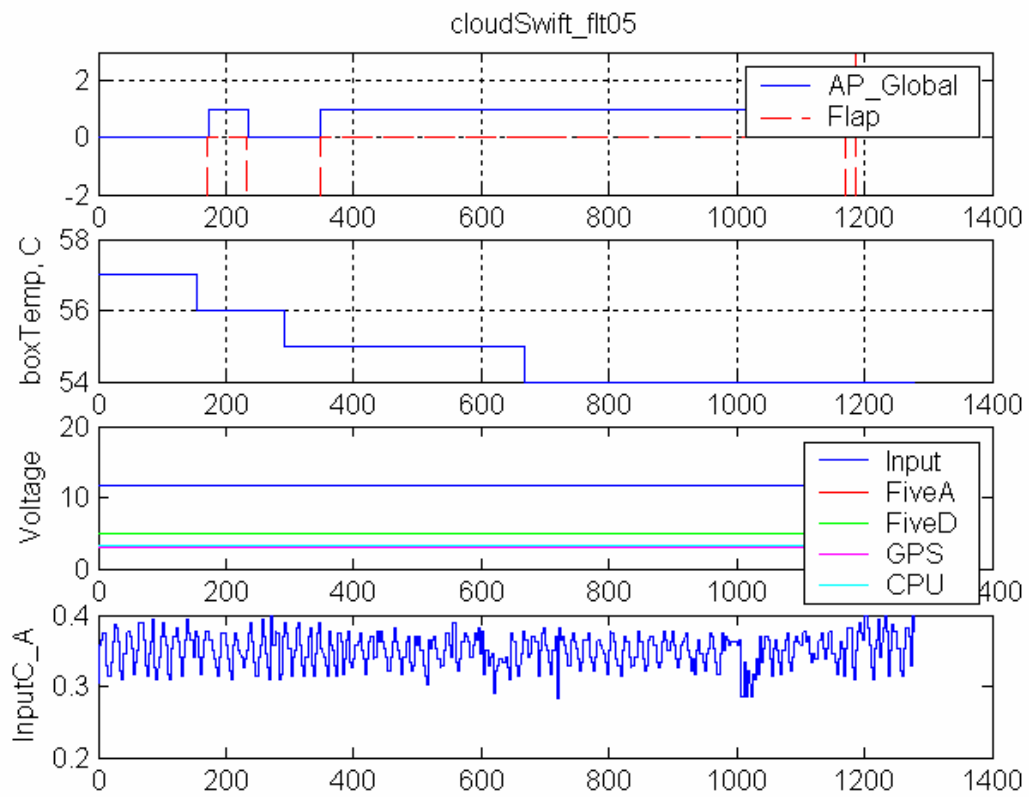
Flight 5

Flight 5 was used to tune the lateral /directional autopilot gains as well as the waypoint tracking gains. The size of the flight course was too large for initial waypoint navigation tests because the aircraft was difficult to see. A closer, smaller flight path would have been better for these tests.



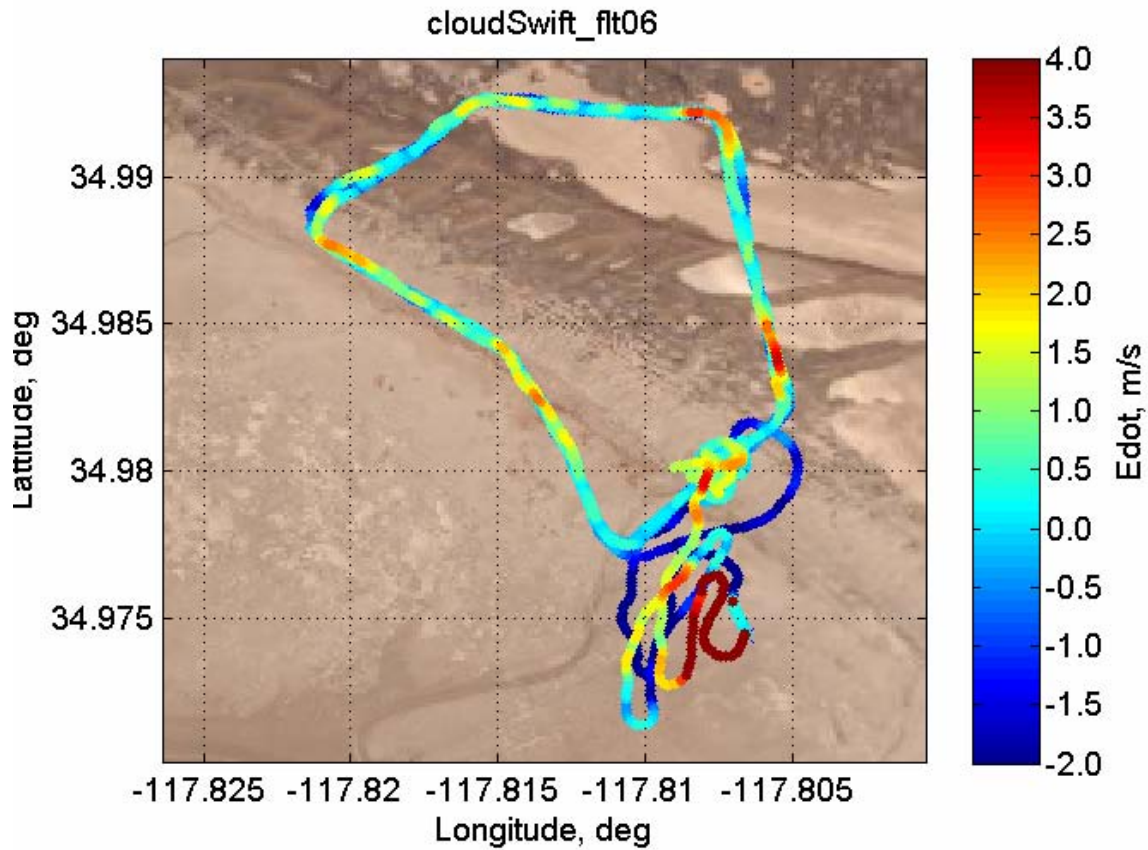


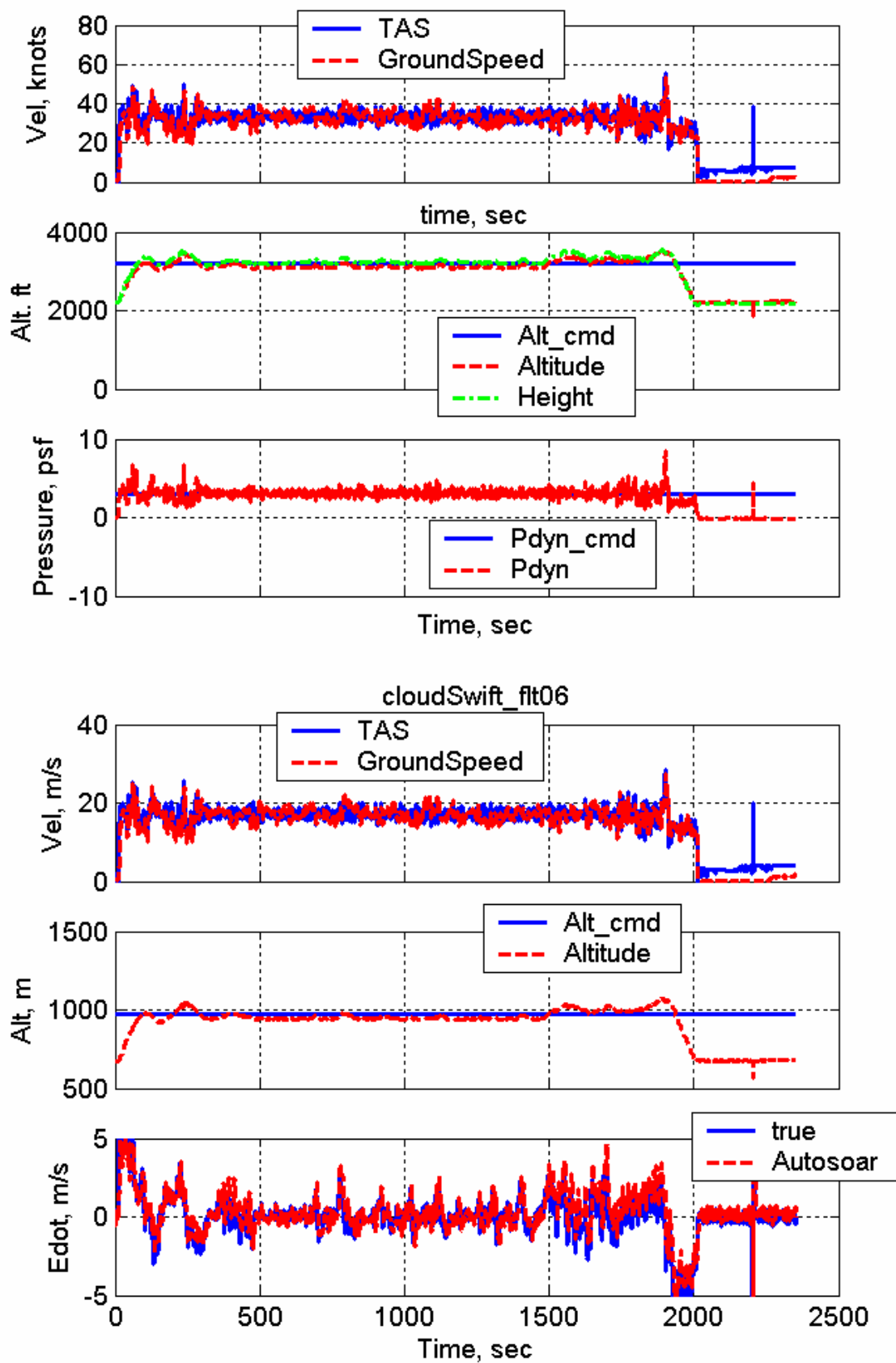


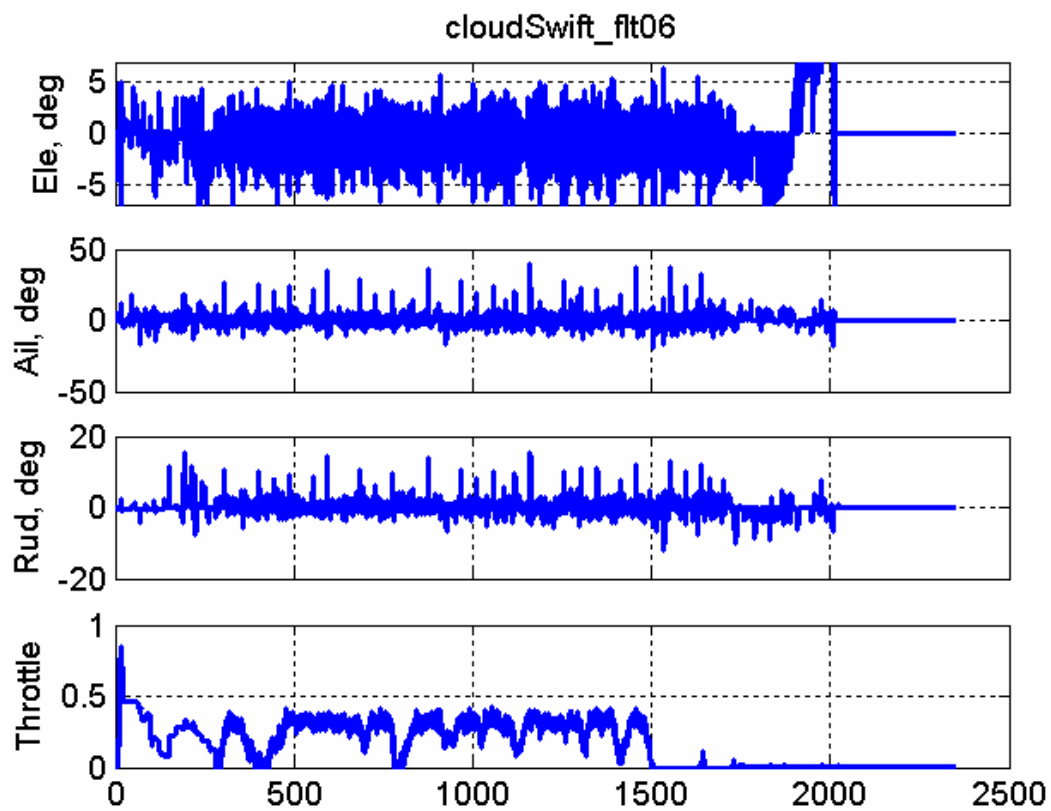
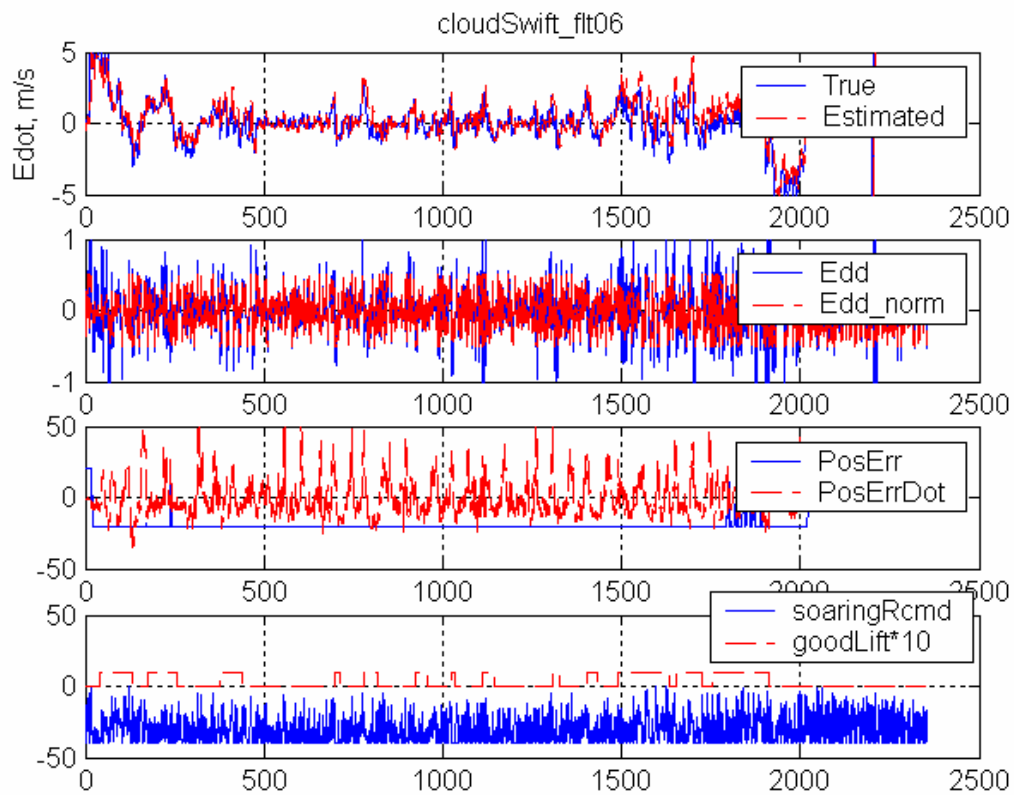


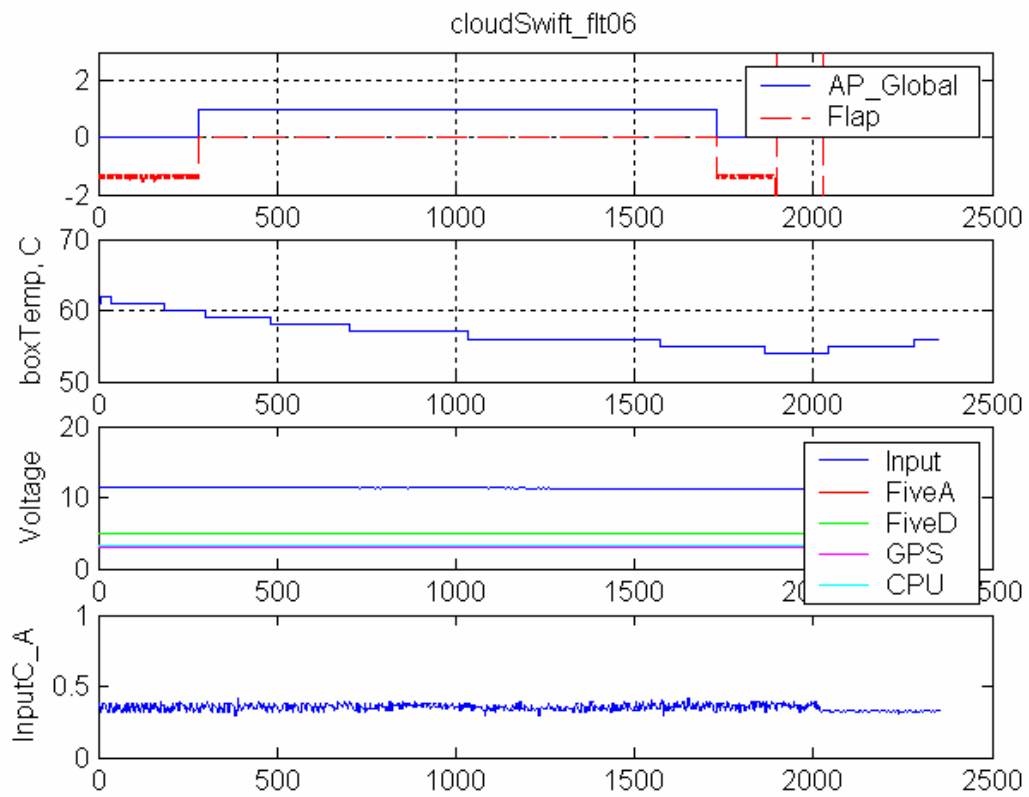
Flight 6

Flight 6 was the first time that the soaring controller was enabled. Problems with the updraft detection logic prevented the controller from engaging. The data included many straight paths through light thermals and was used to tune the updraft identification logic. Individual plots for some of the thermals and for each complete loop, or circuit around the flight path are shown.



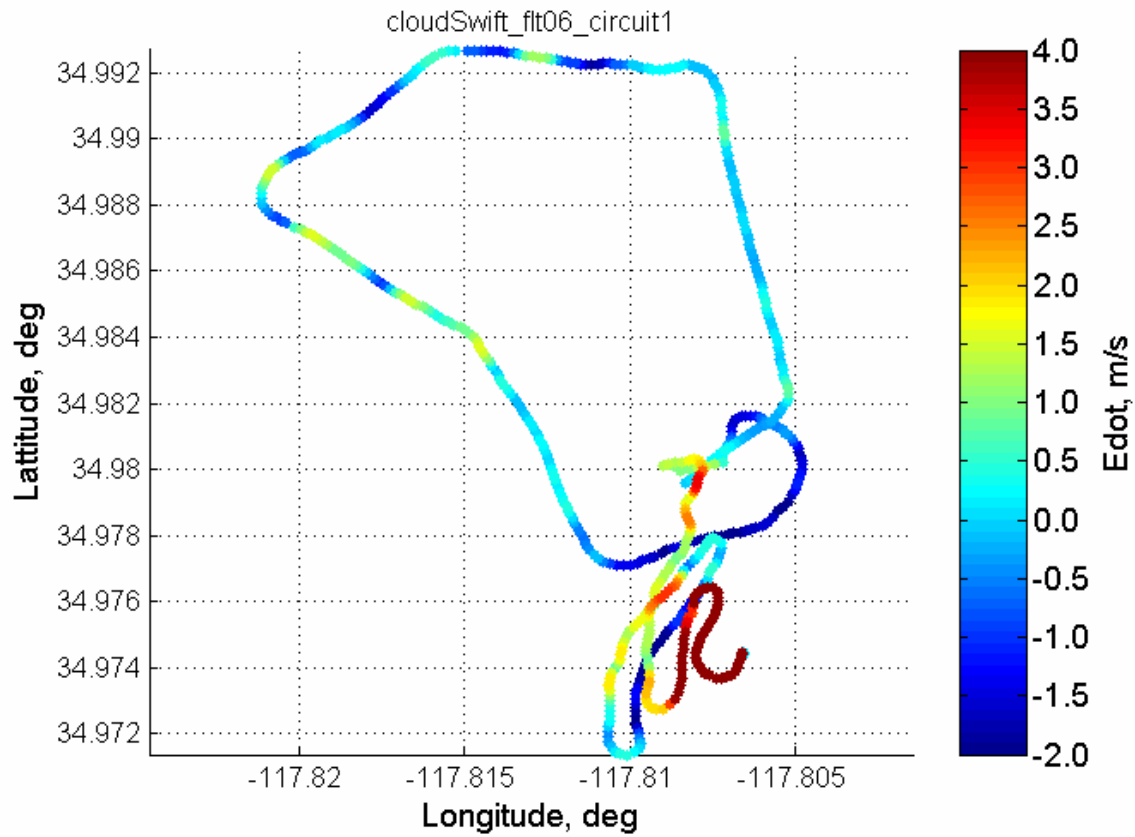


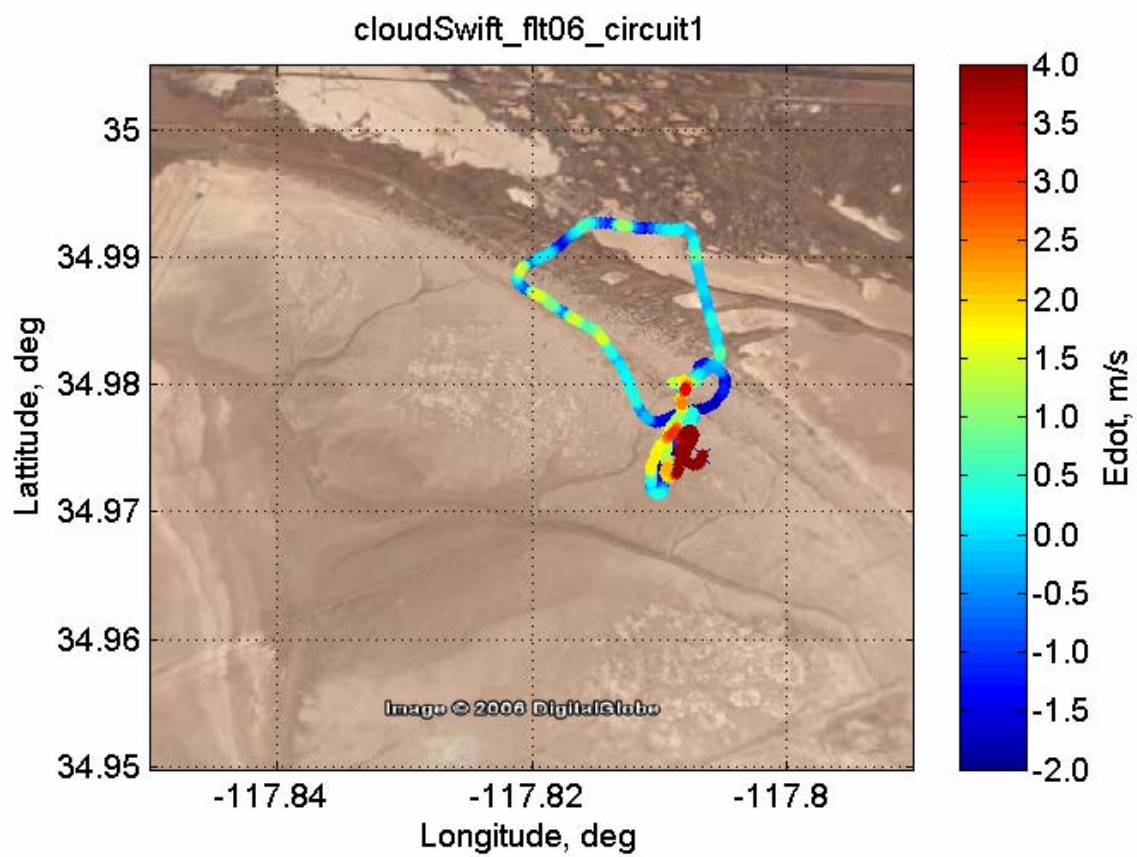


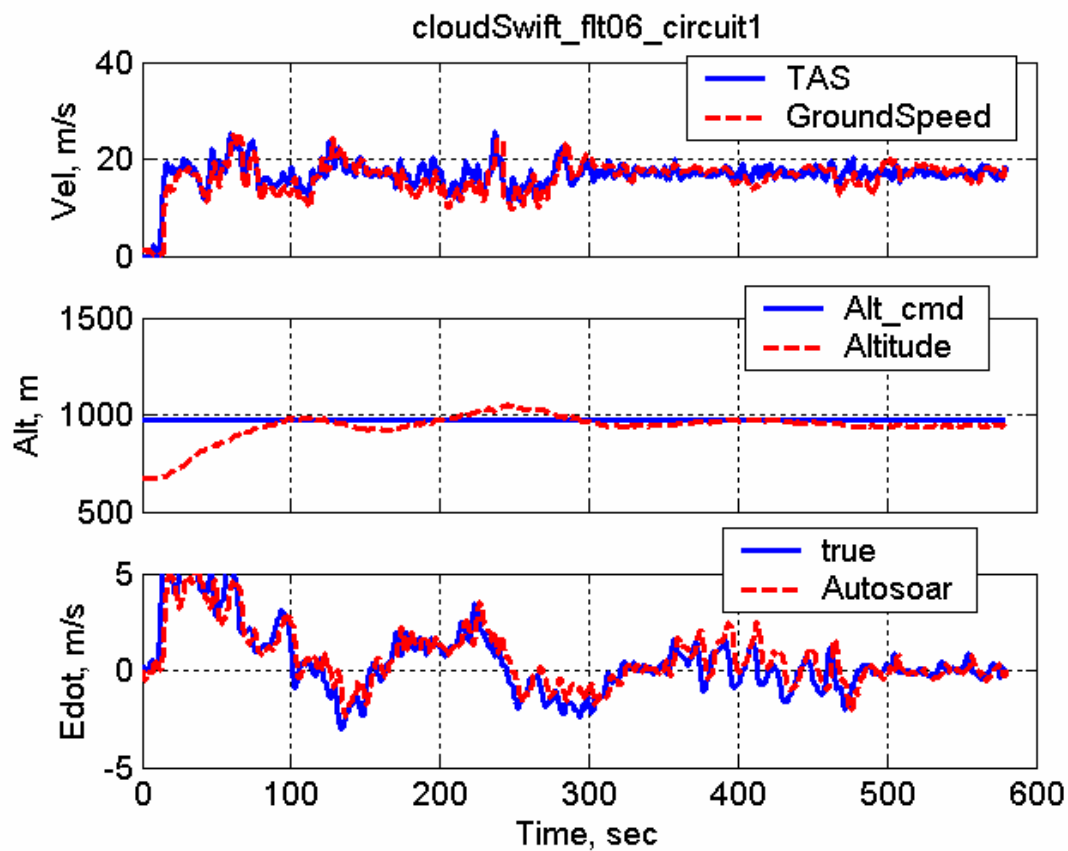
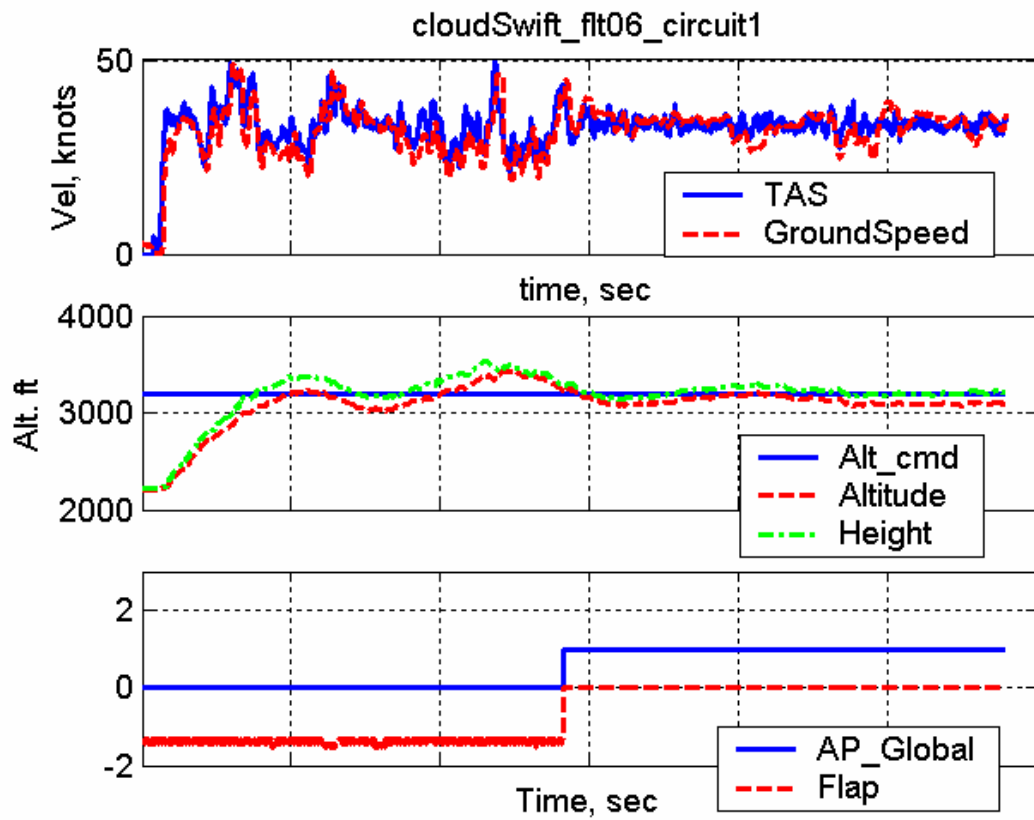


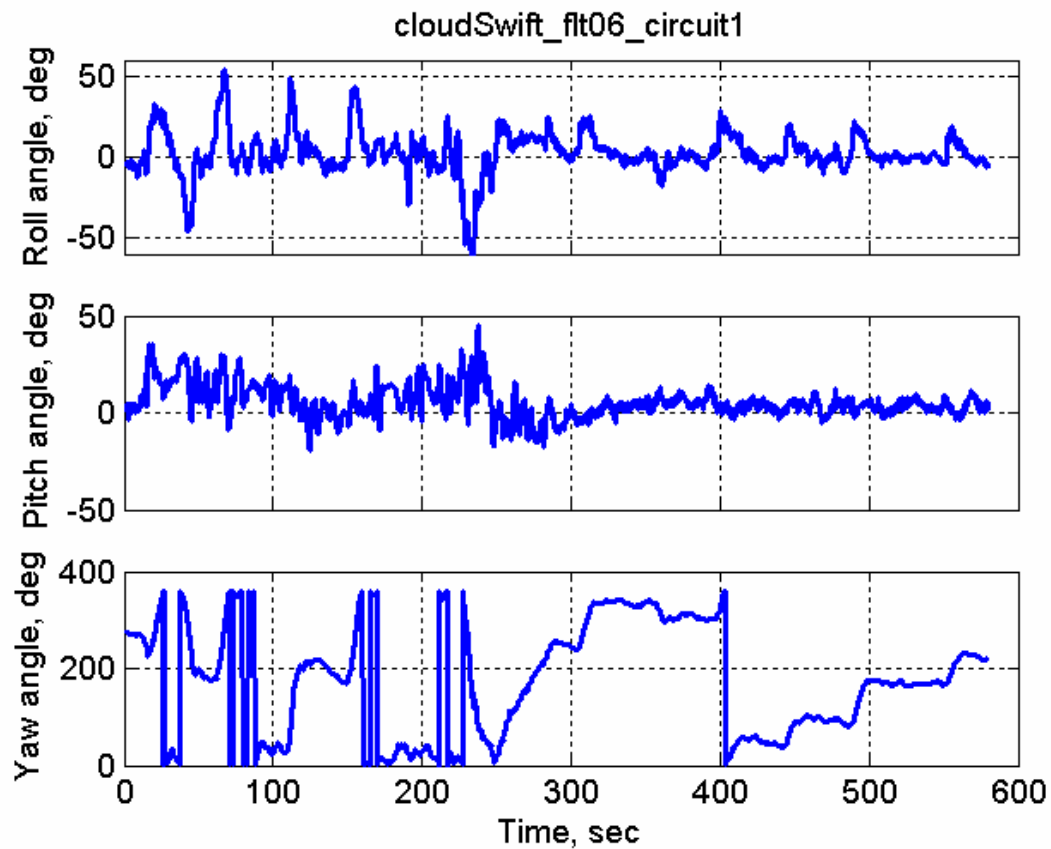
Flight 06, circuit 1

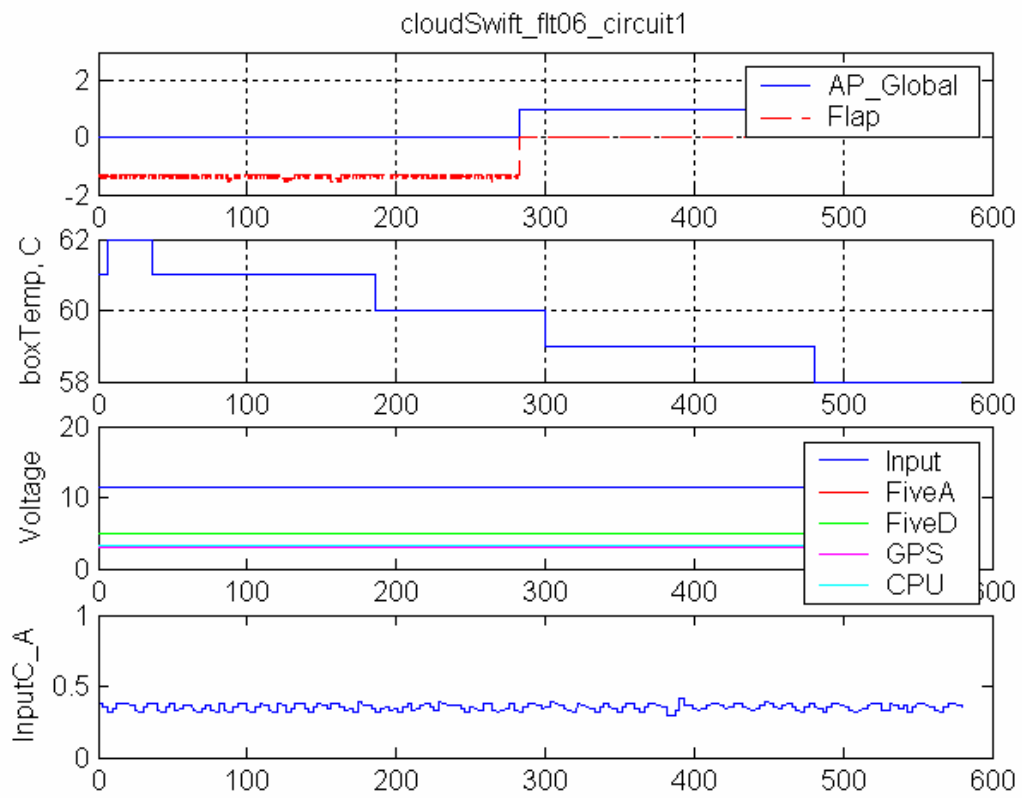
Circuit 1 is the first circuit around the flight path during flight 6. Takeoff and initial climb to altitude is included here in red. No significant thermals were encountered during this circuit. Poor altitude tracking is noted.





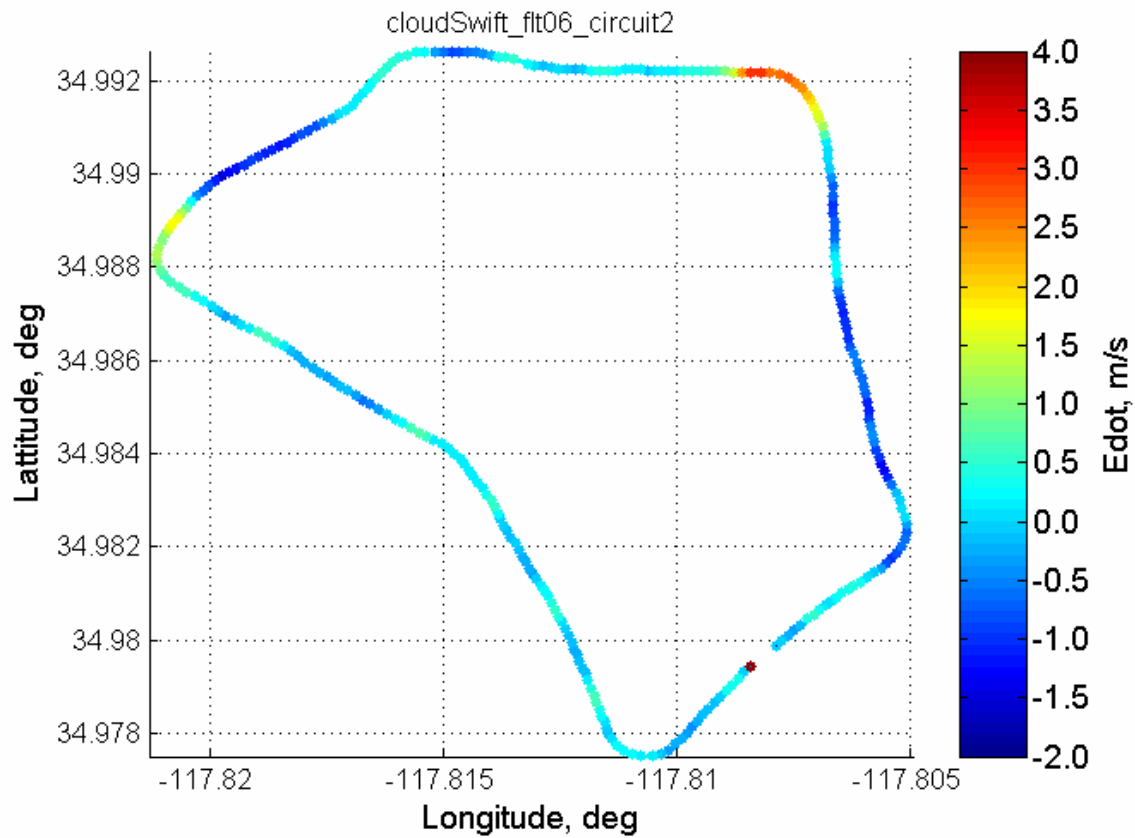


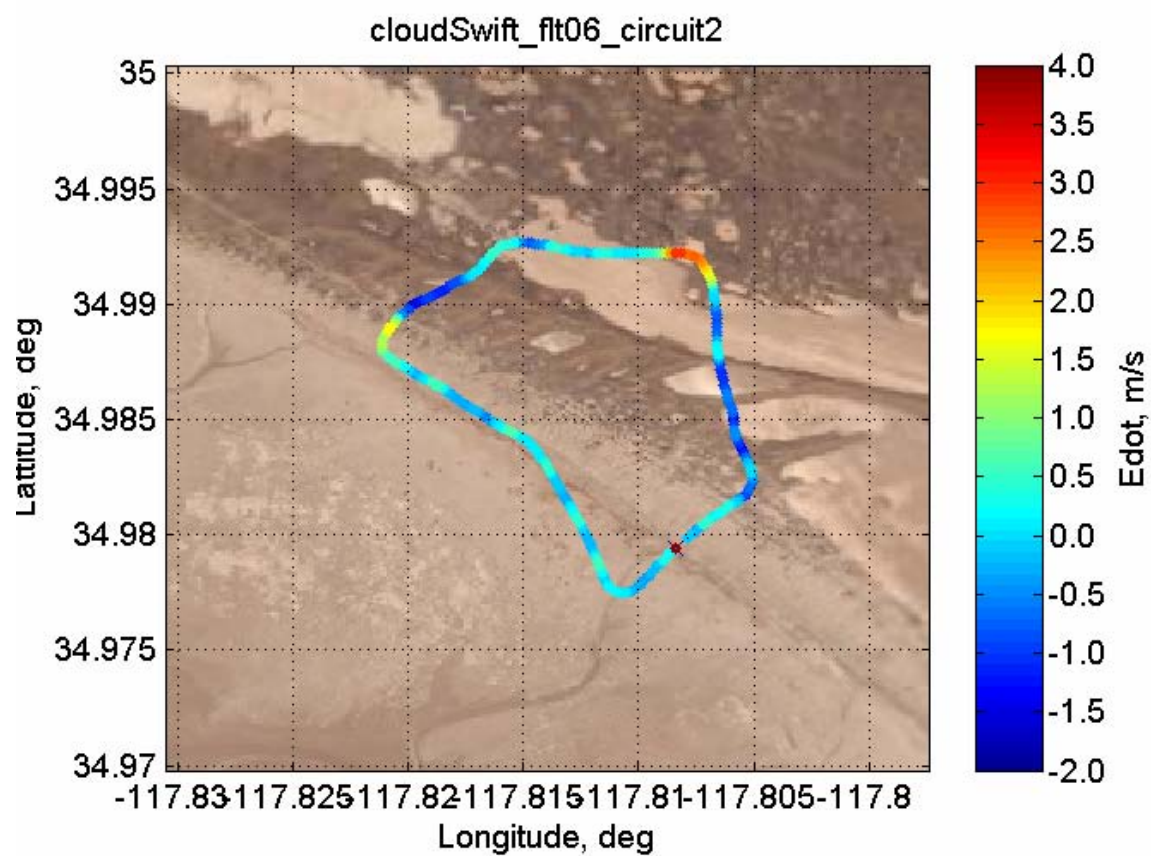


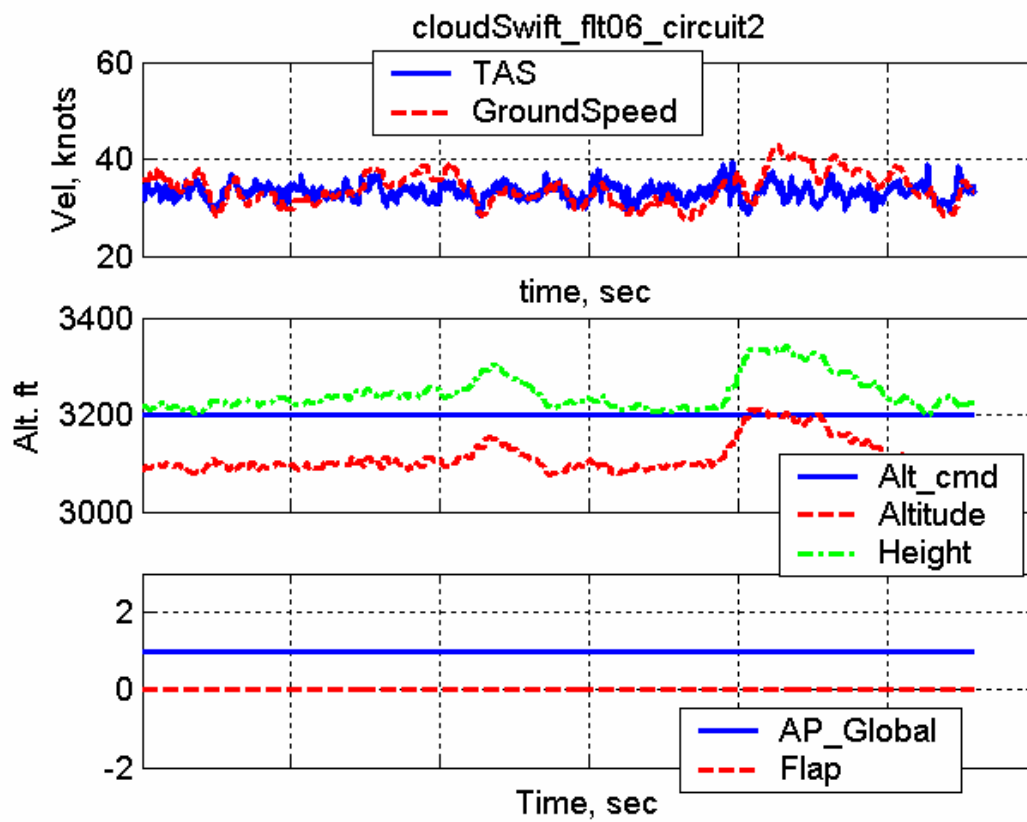
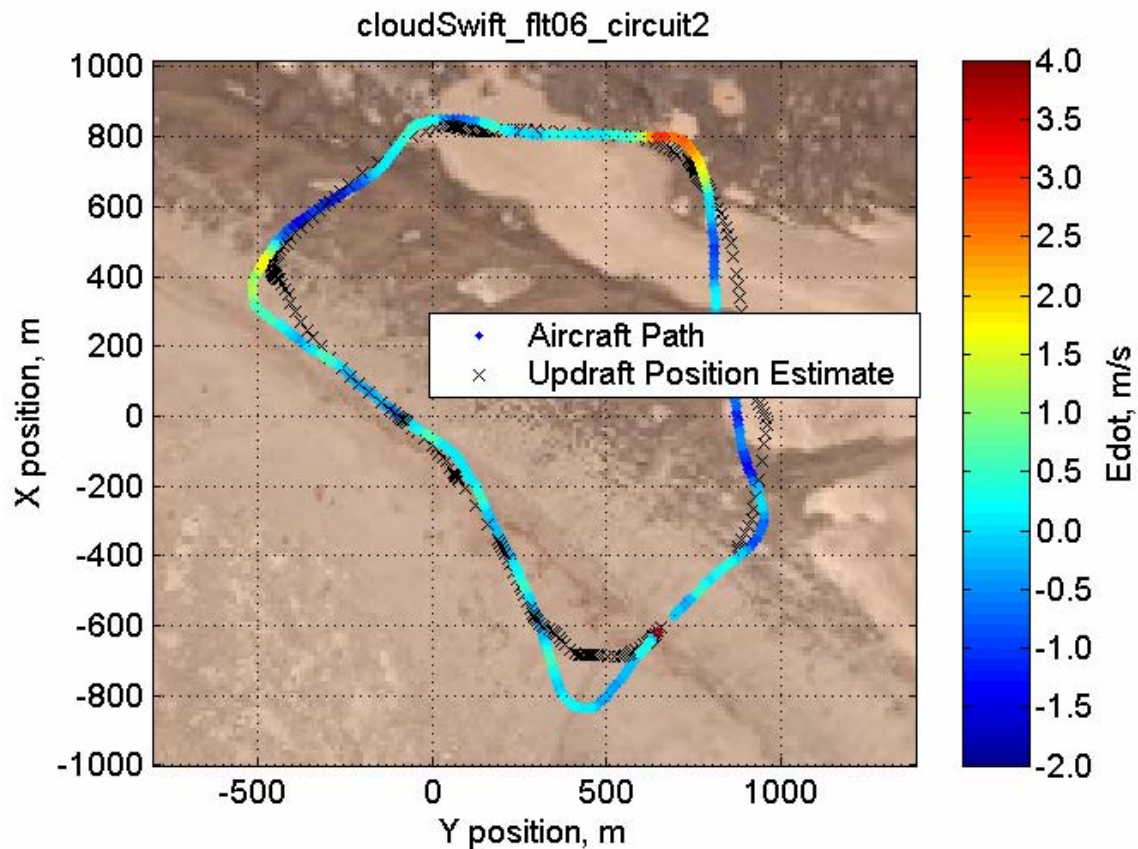


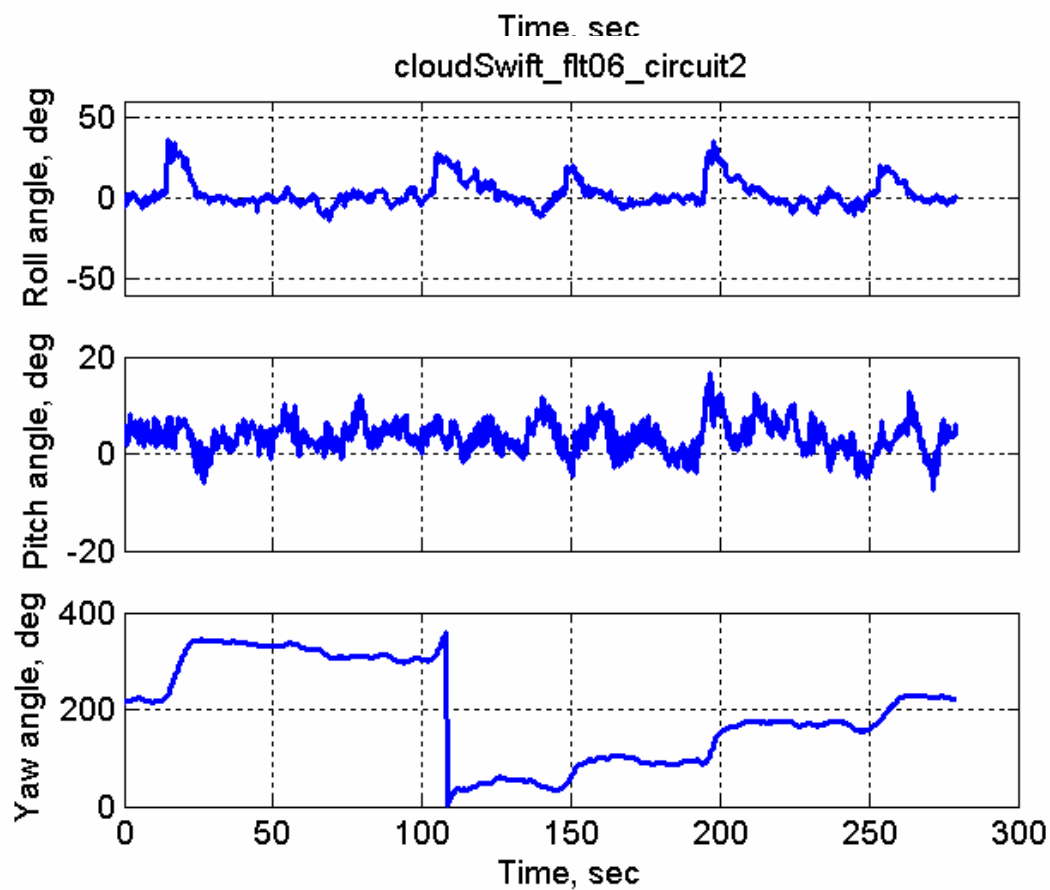
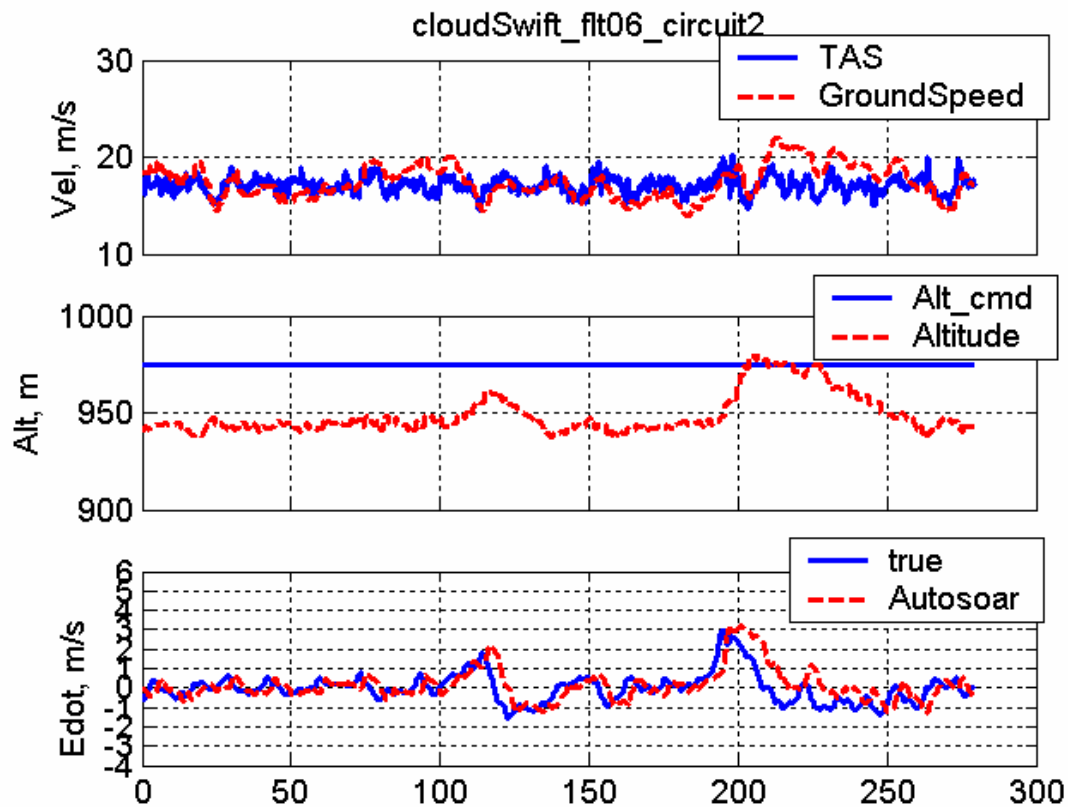
Flight 06, circuit 2

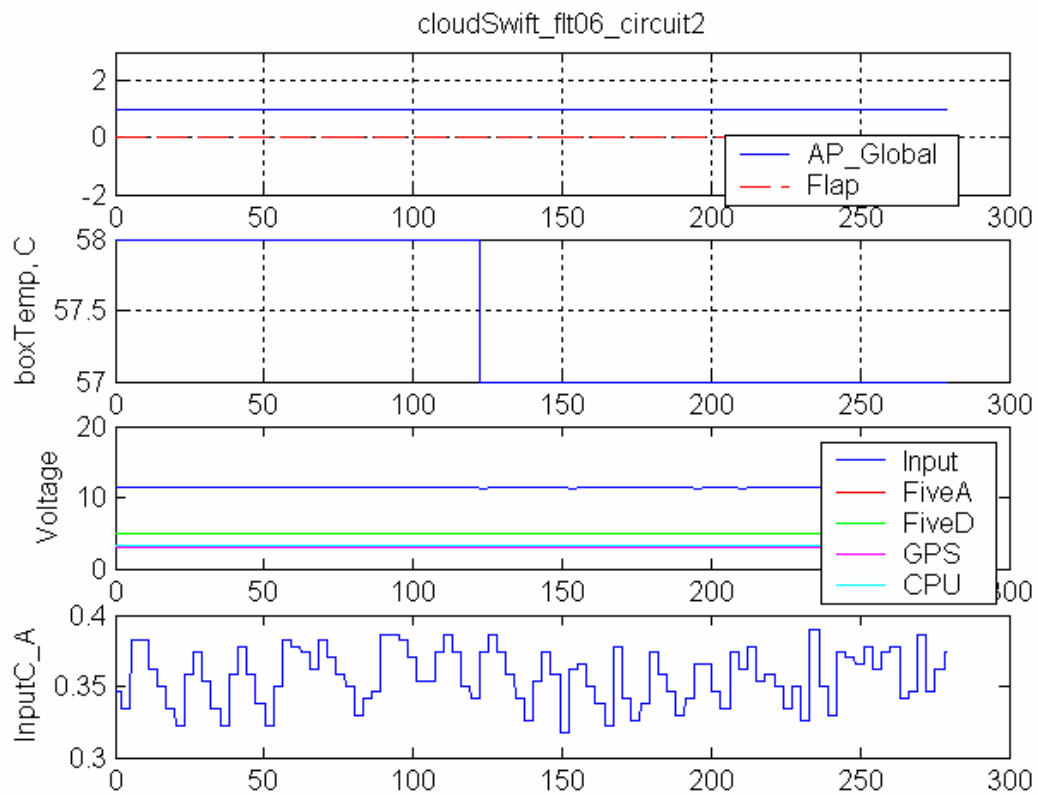
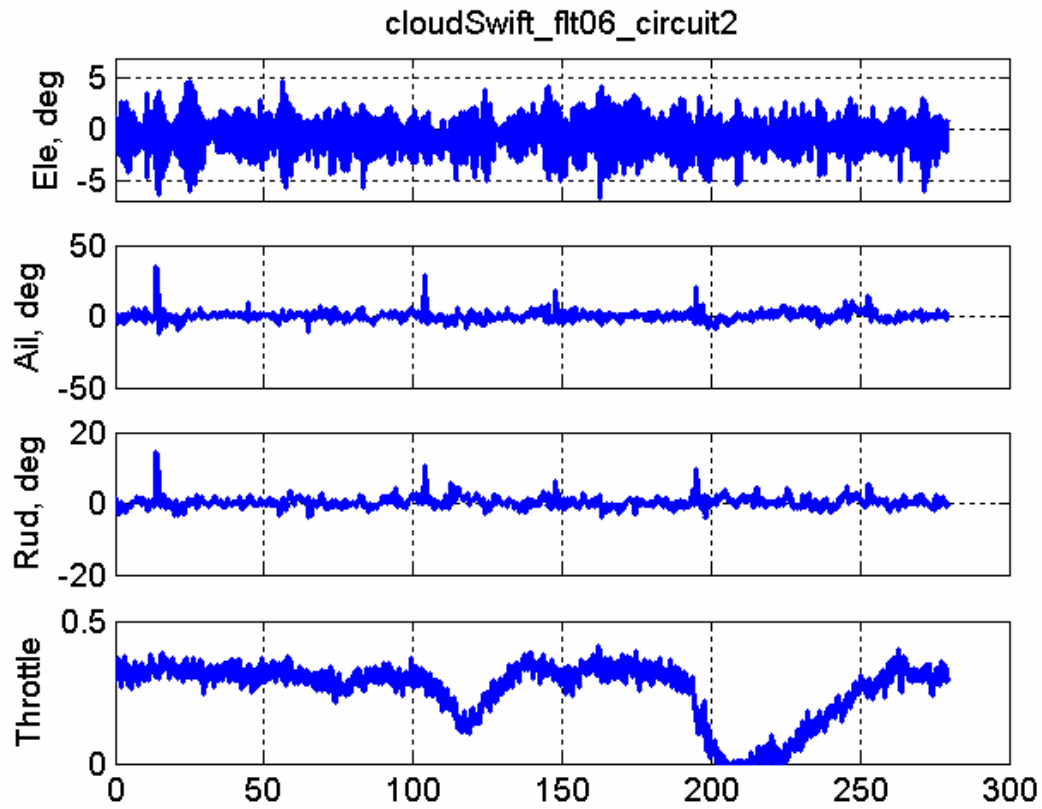
Circuit 2 is the second circuit around the flight path during flight 6. Two thermals were encountered during this flight, and were triggered by the updraft detection logic of version 6_52. Unfortunately, they were not triggered by the SW version used in flight 6 (ver 6_40). Note the sharp triangular shape of the thermals. These are Konovalov type-b thermals, small and pointy

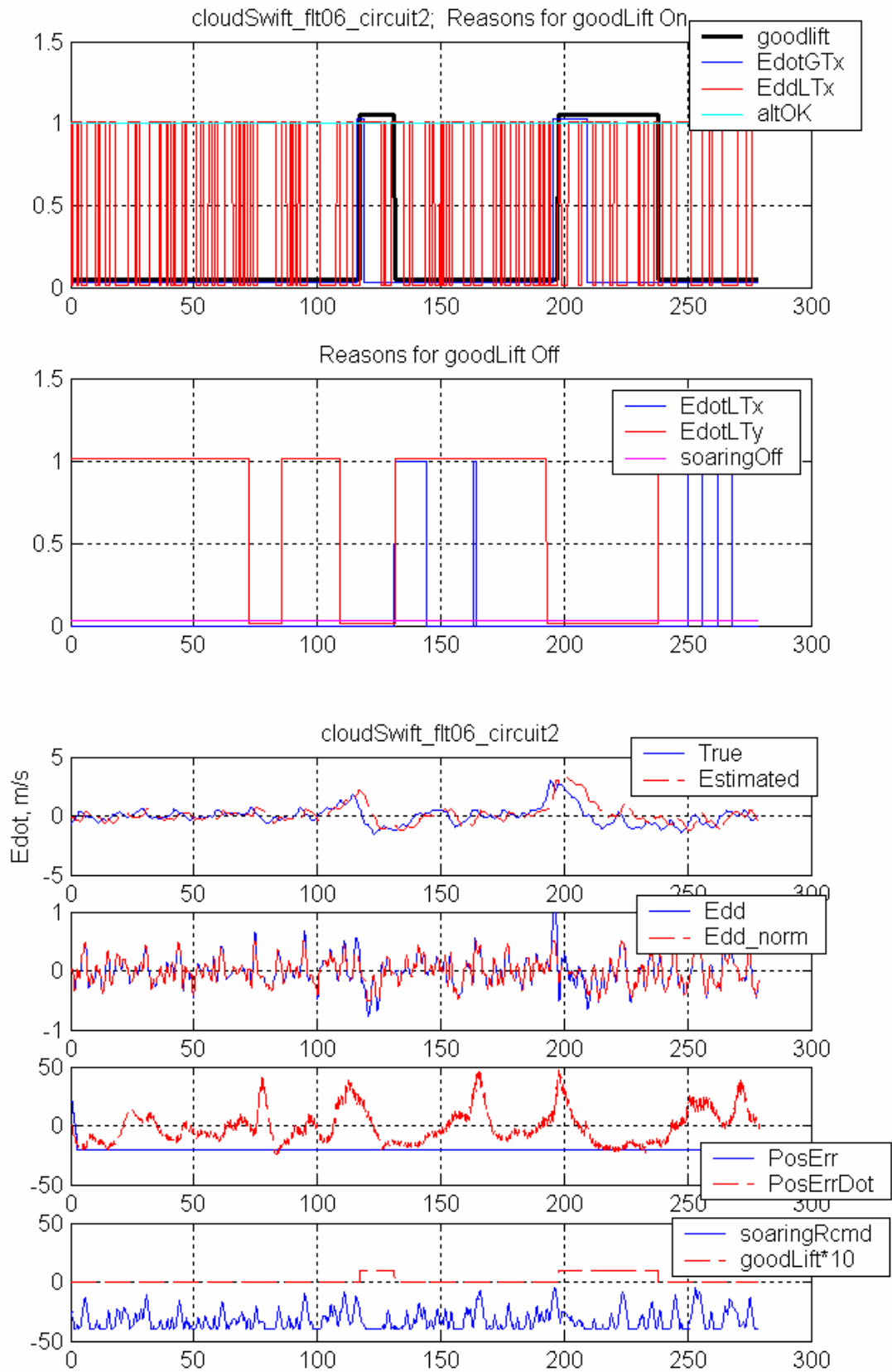






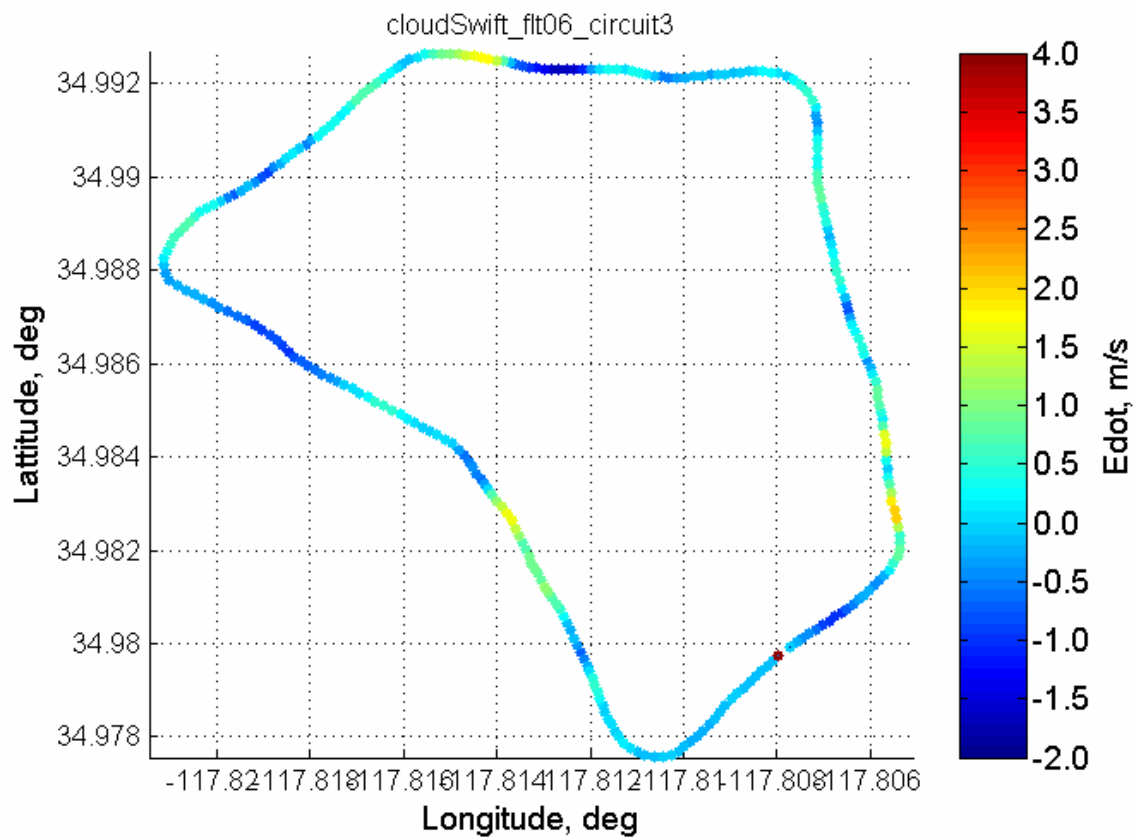


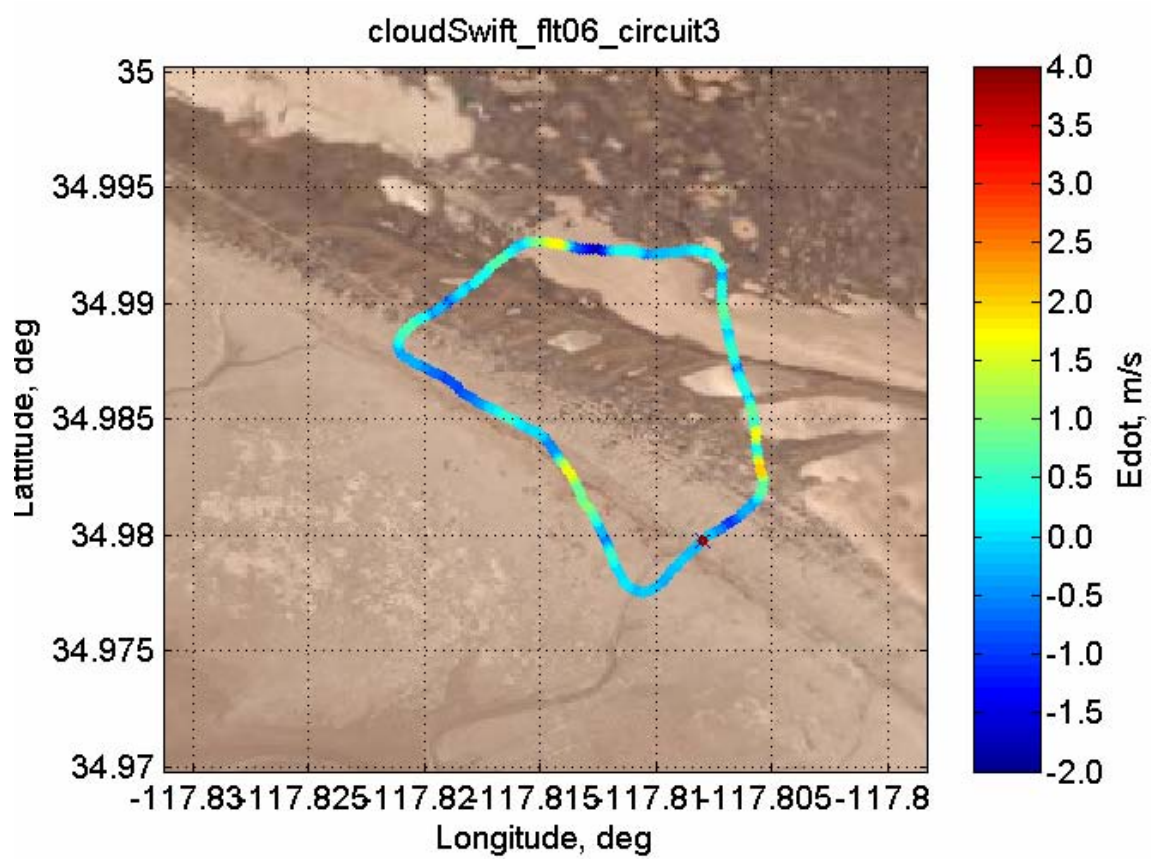


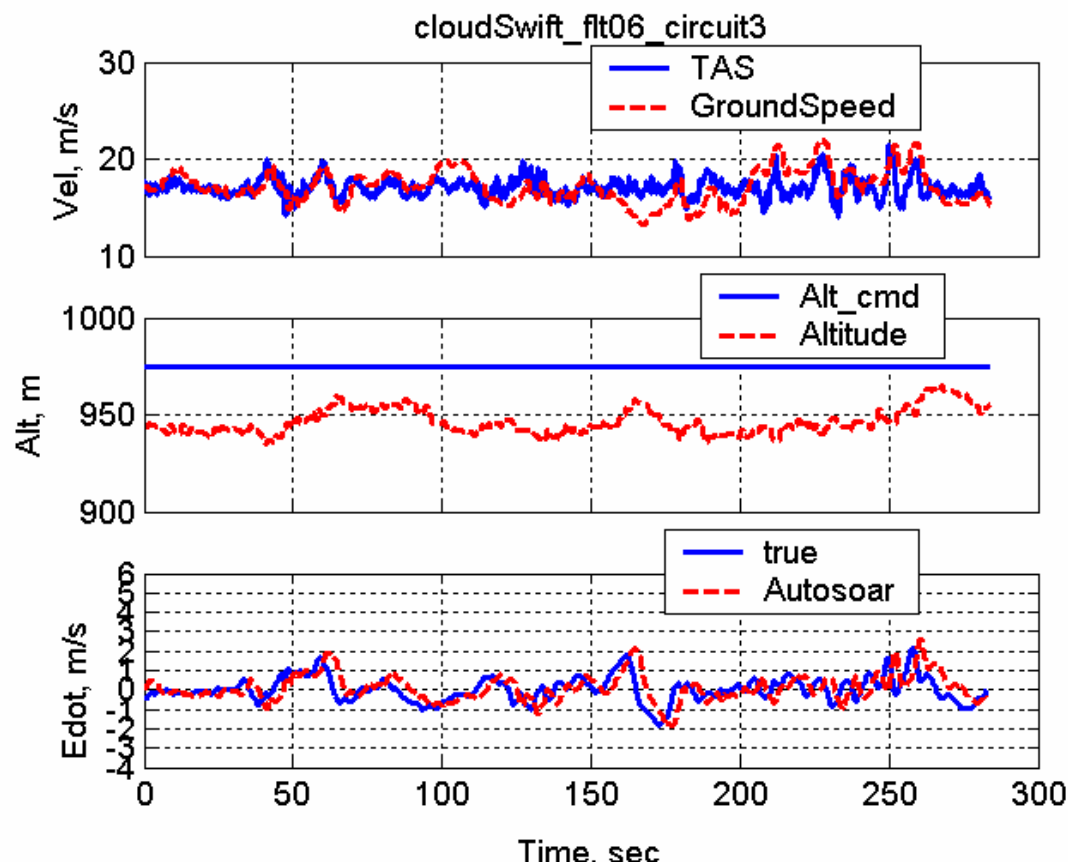
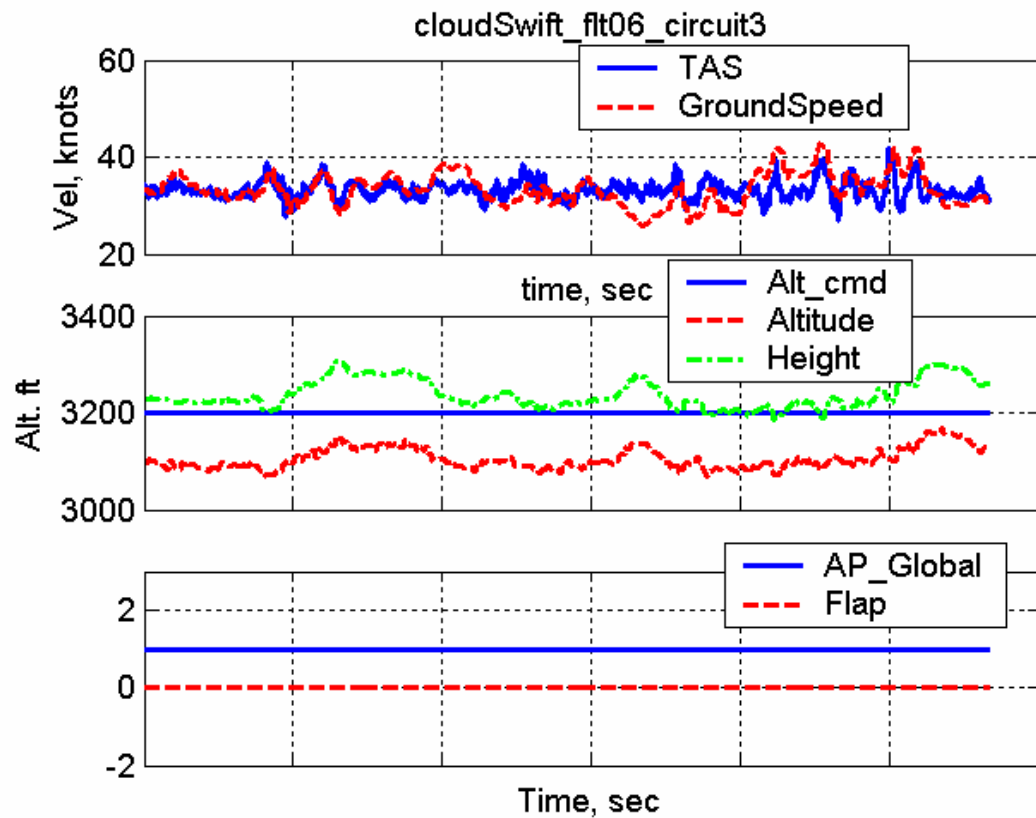


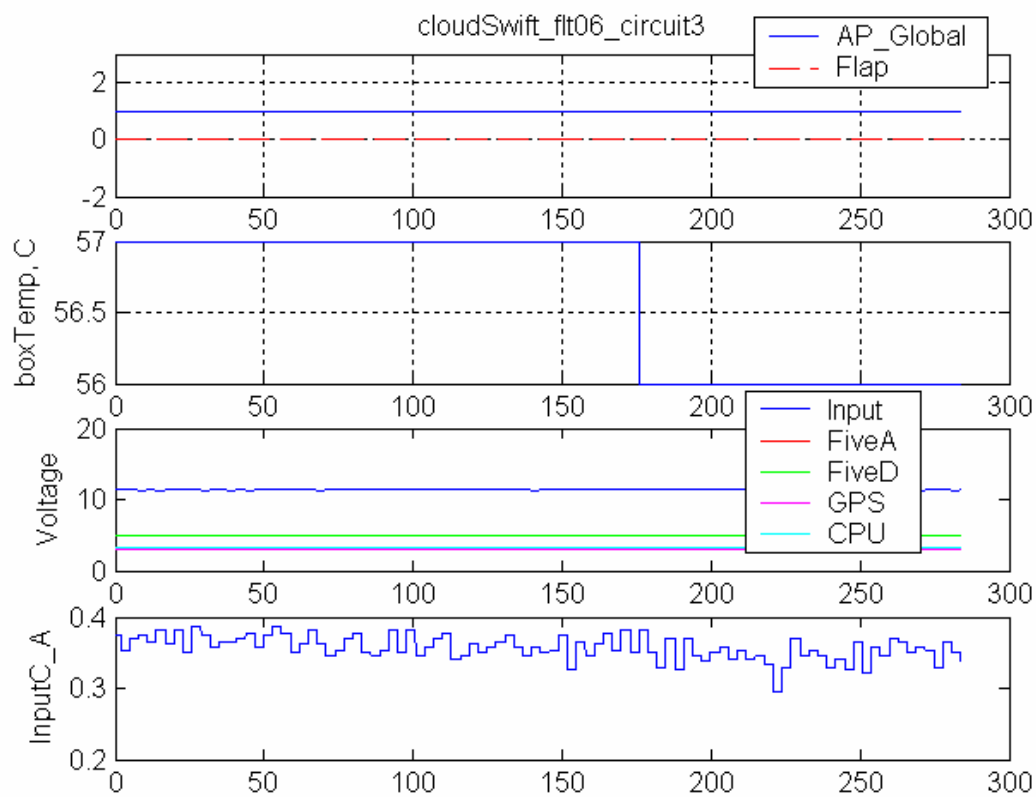
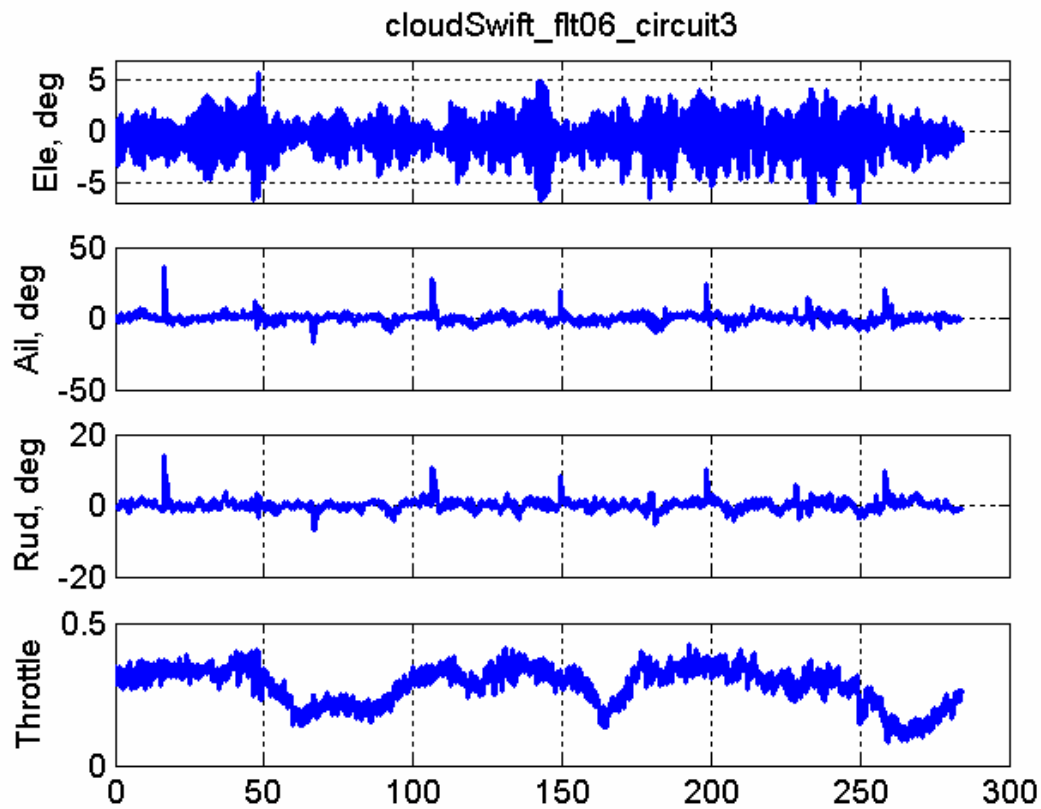
Flight 6, circuit 3

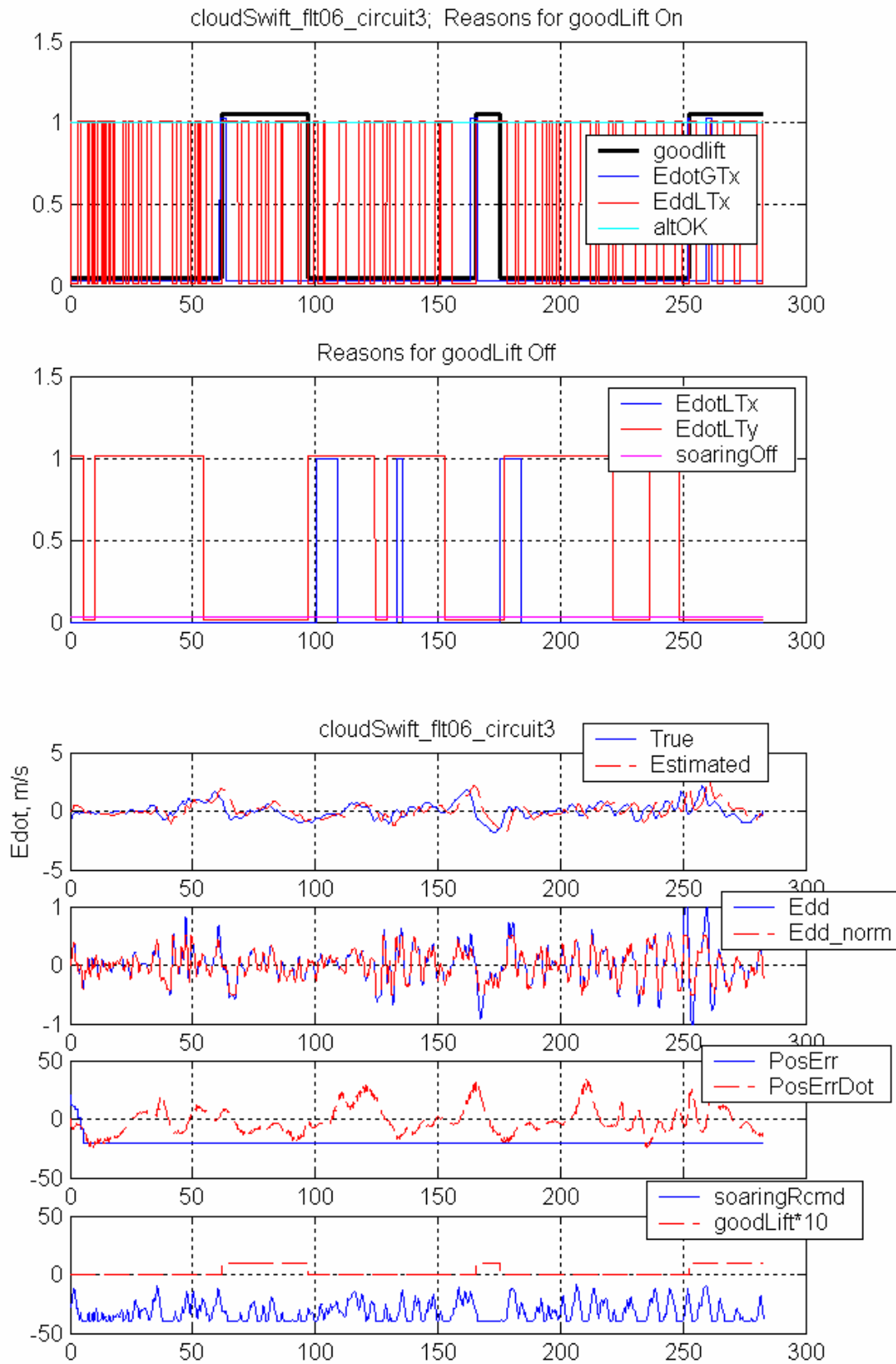
Three thermals were encountered during this circuit. Note the irregular structure of the thermals and the presence of downdrafts before and after the thermals.





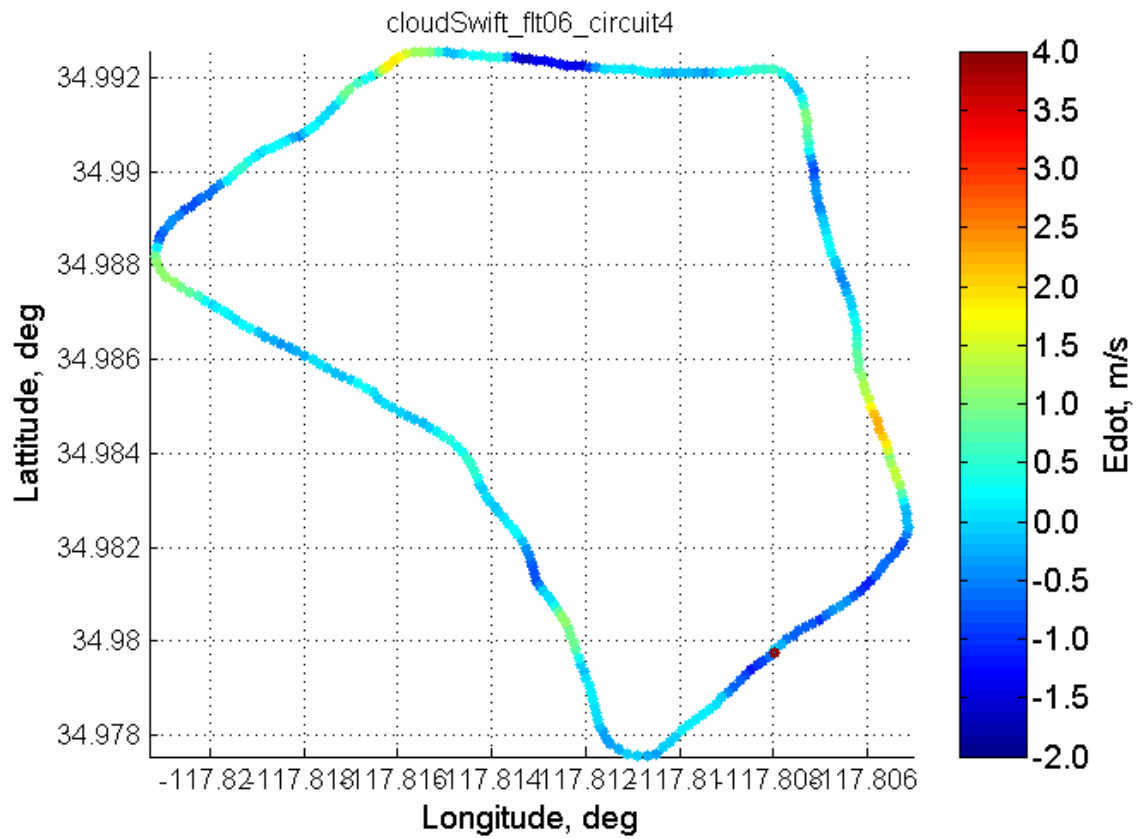


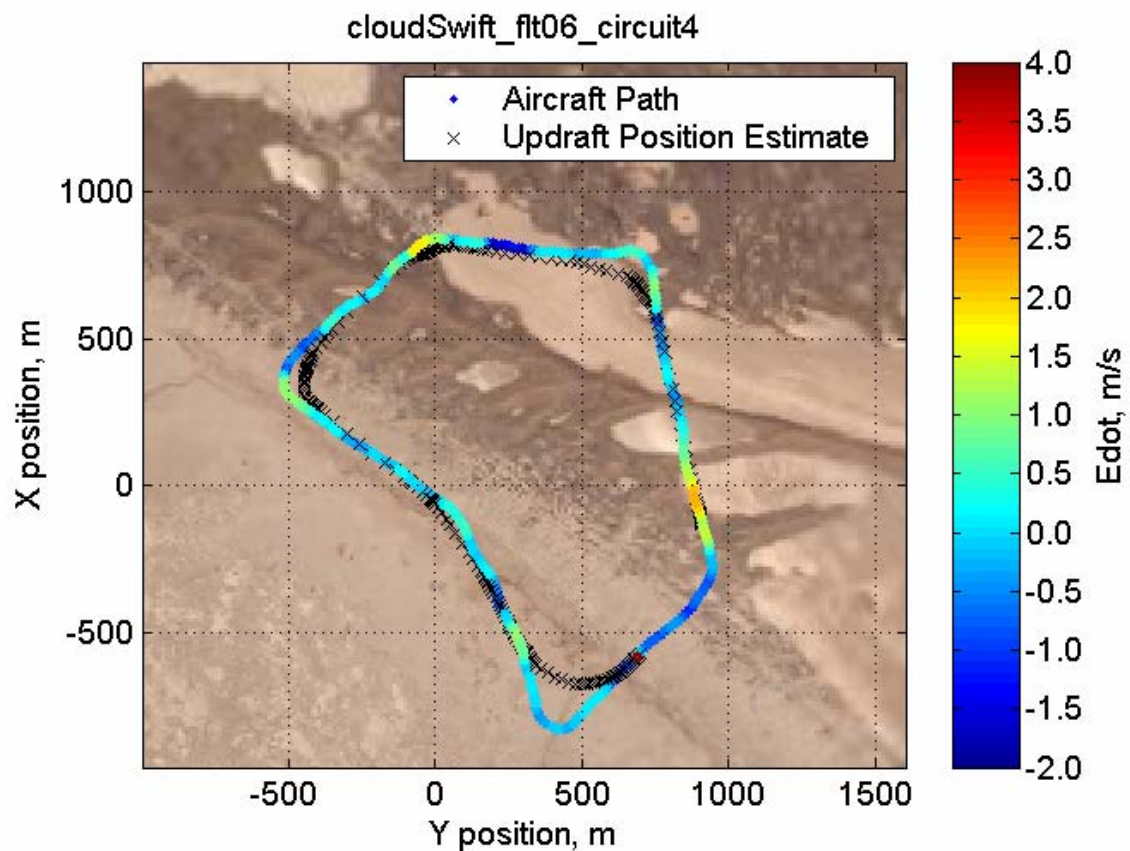
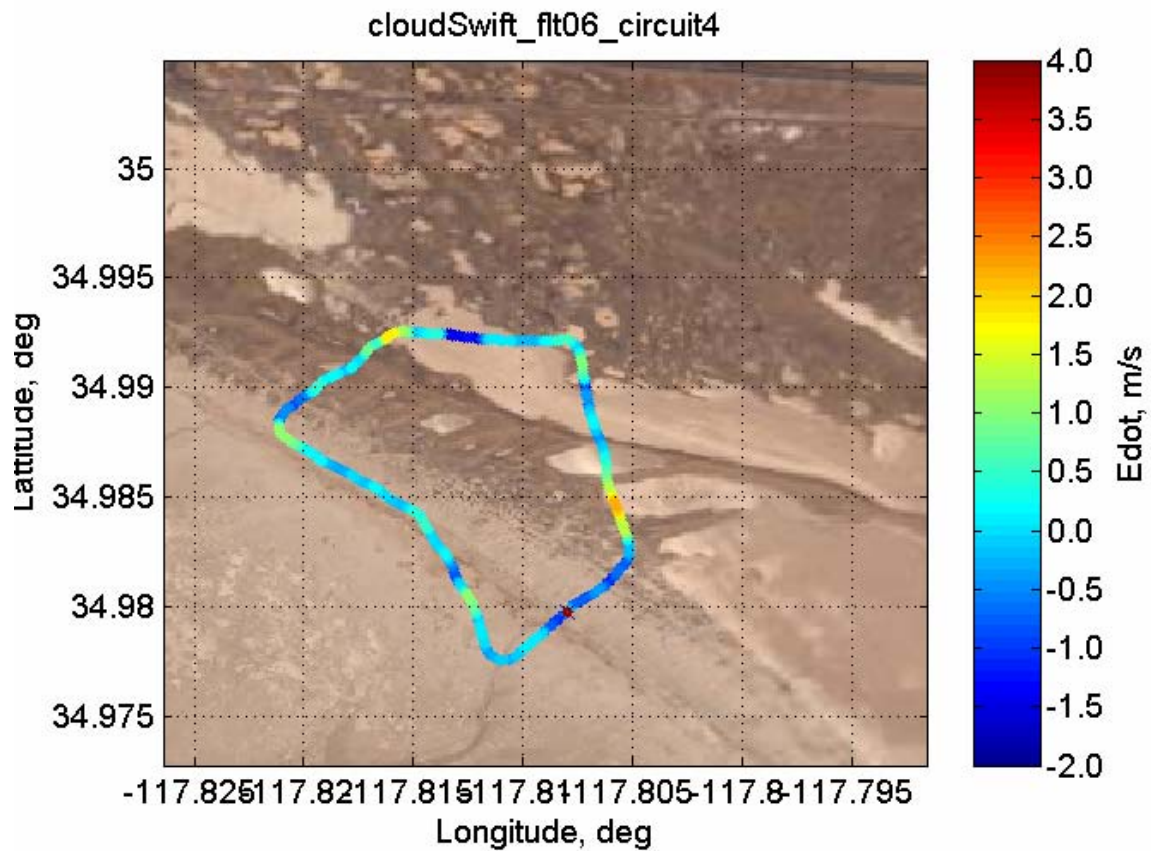


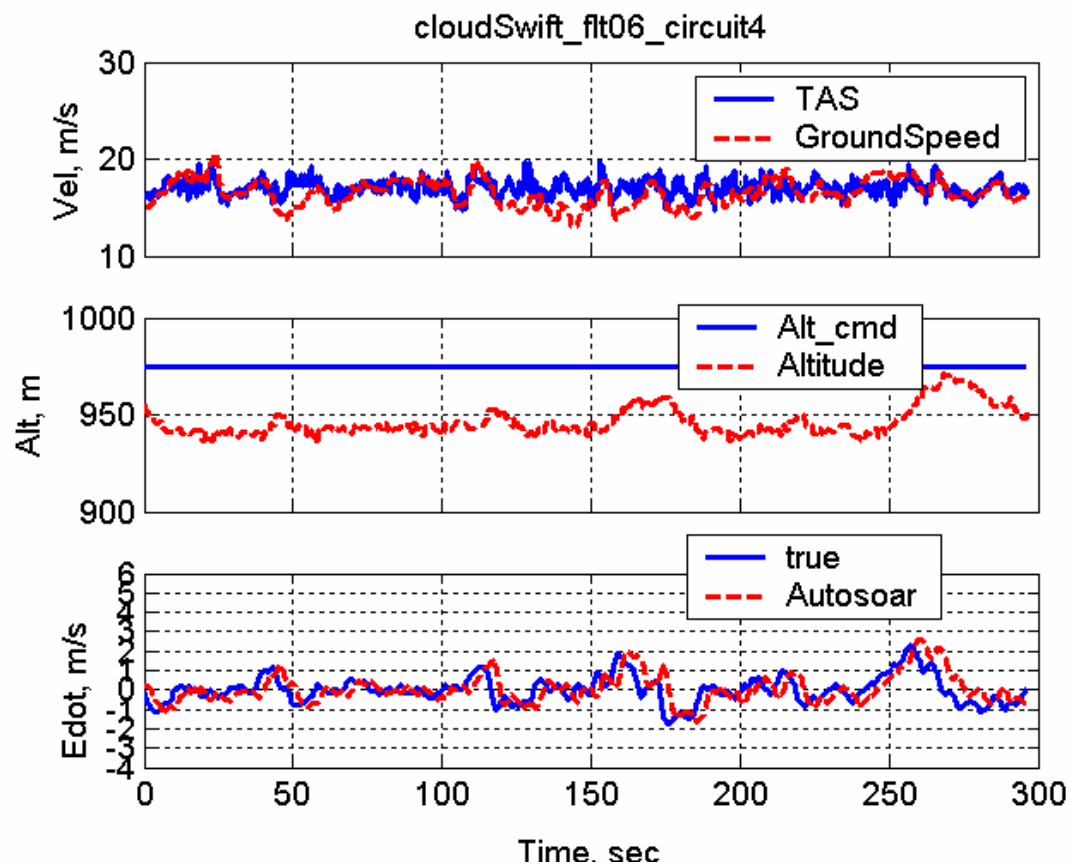
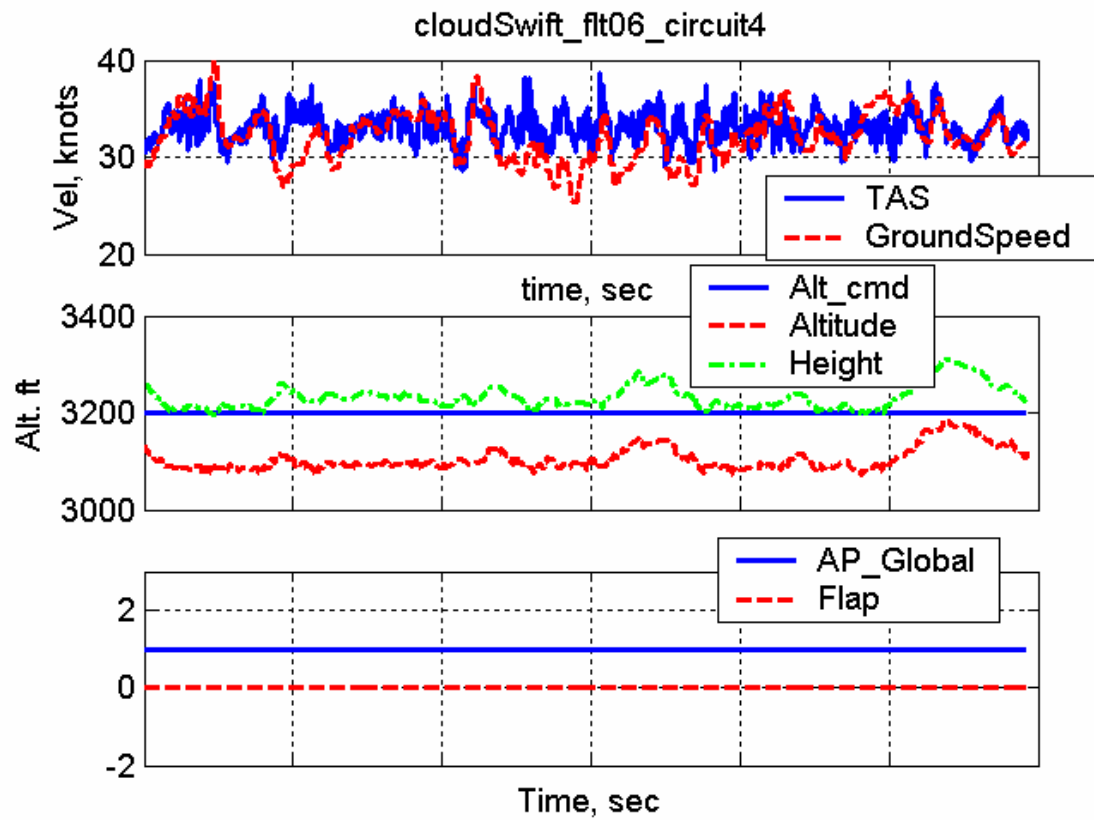


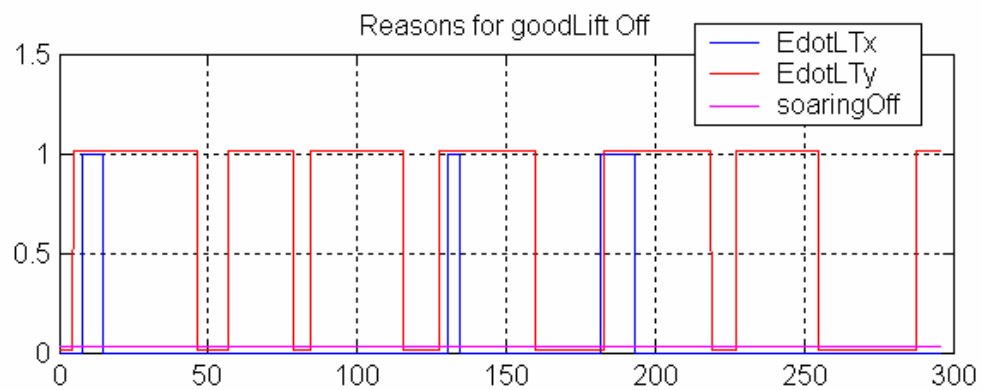
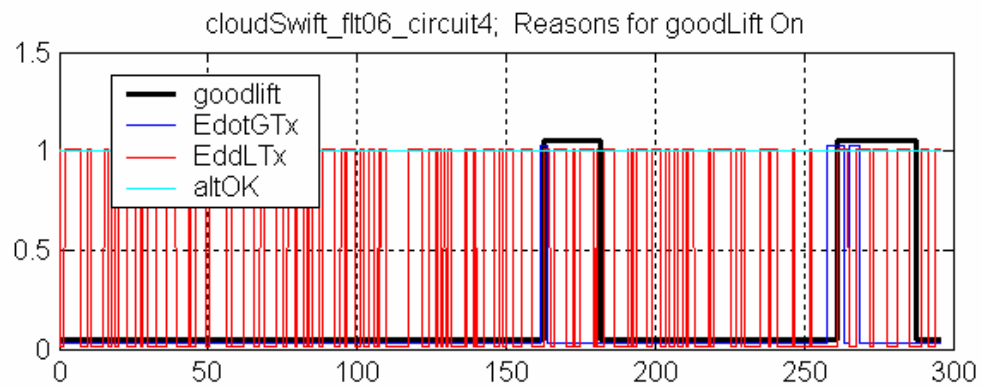
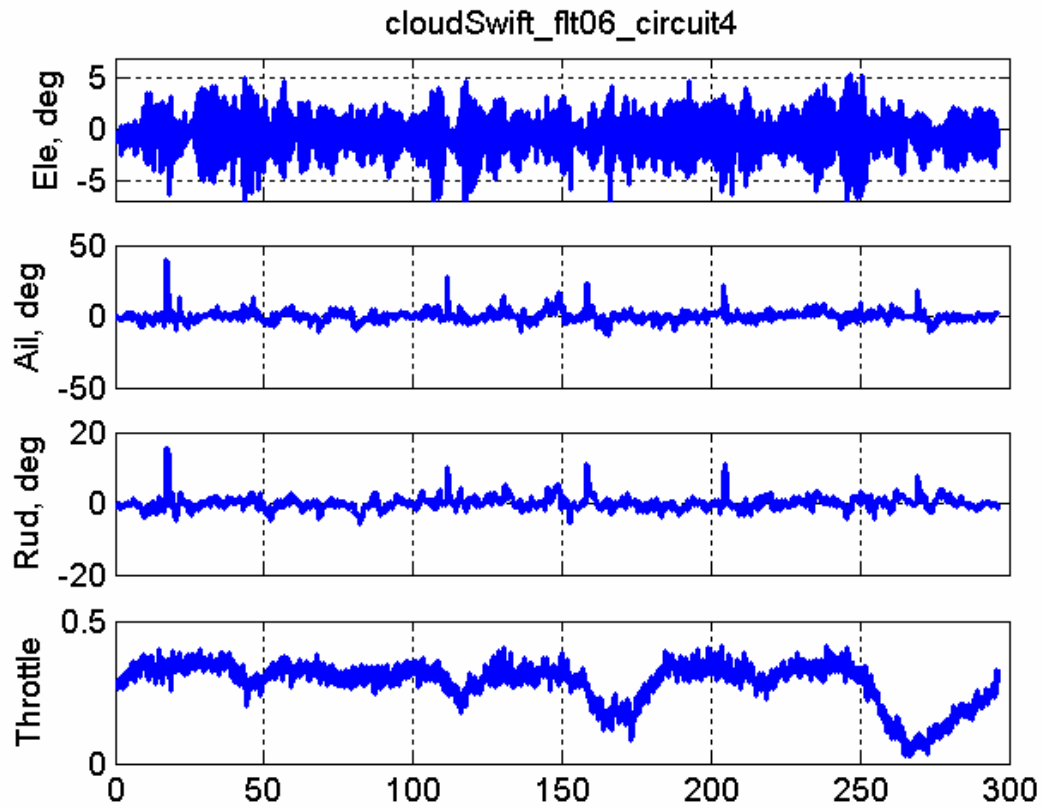
Flight 6, circuit 4

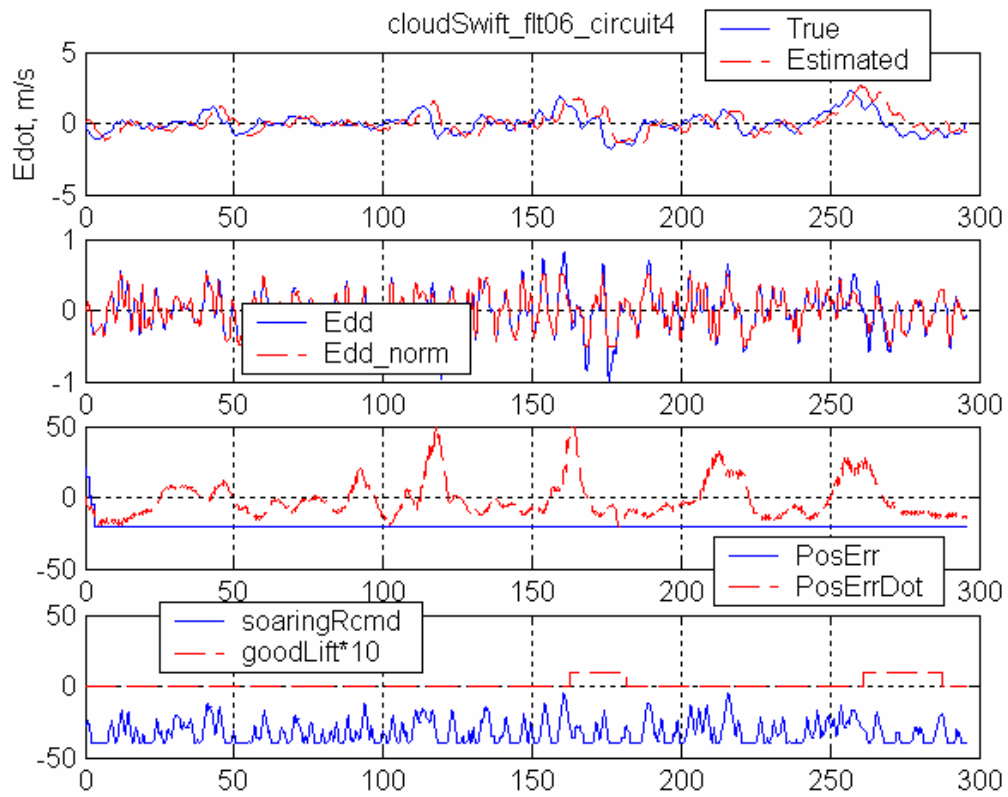
Two thermals were encountered during this circuit.





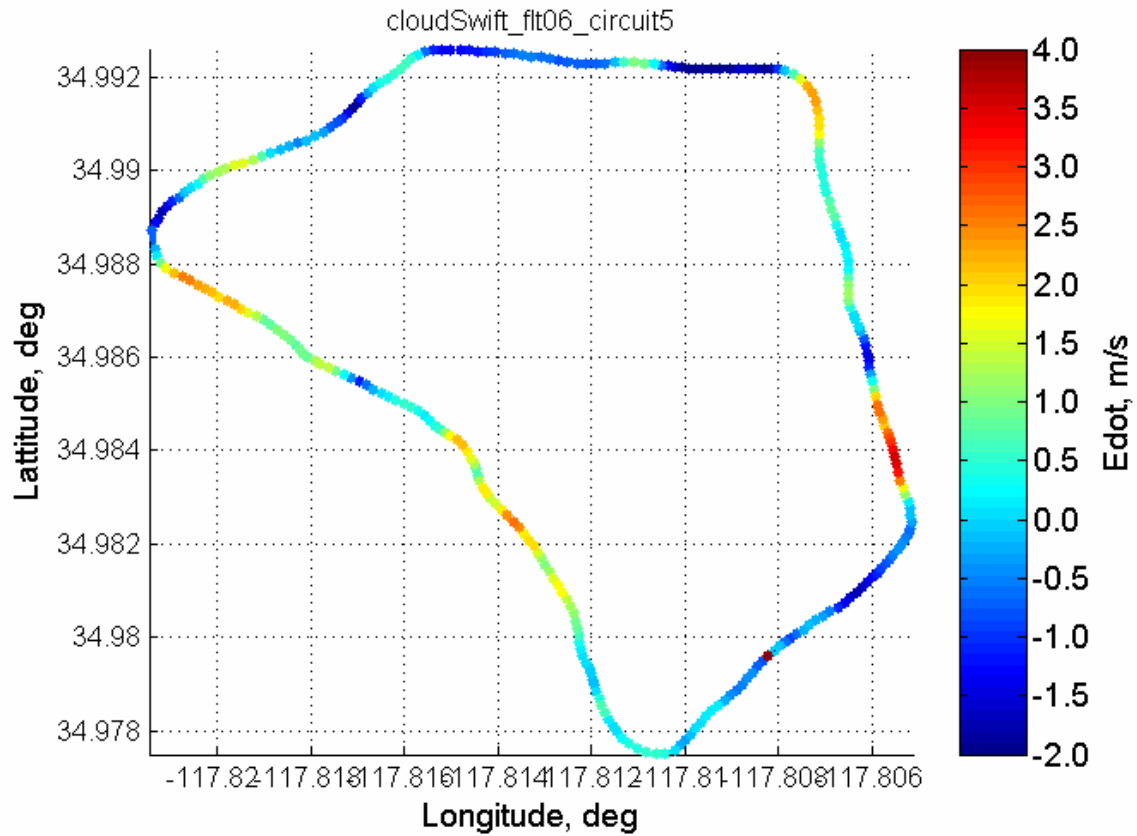


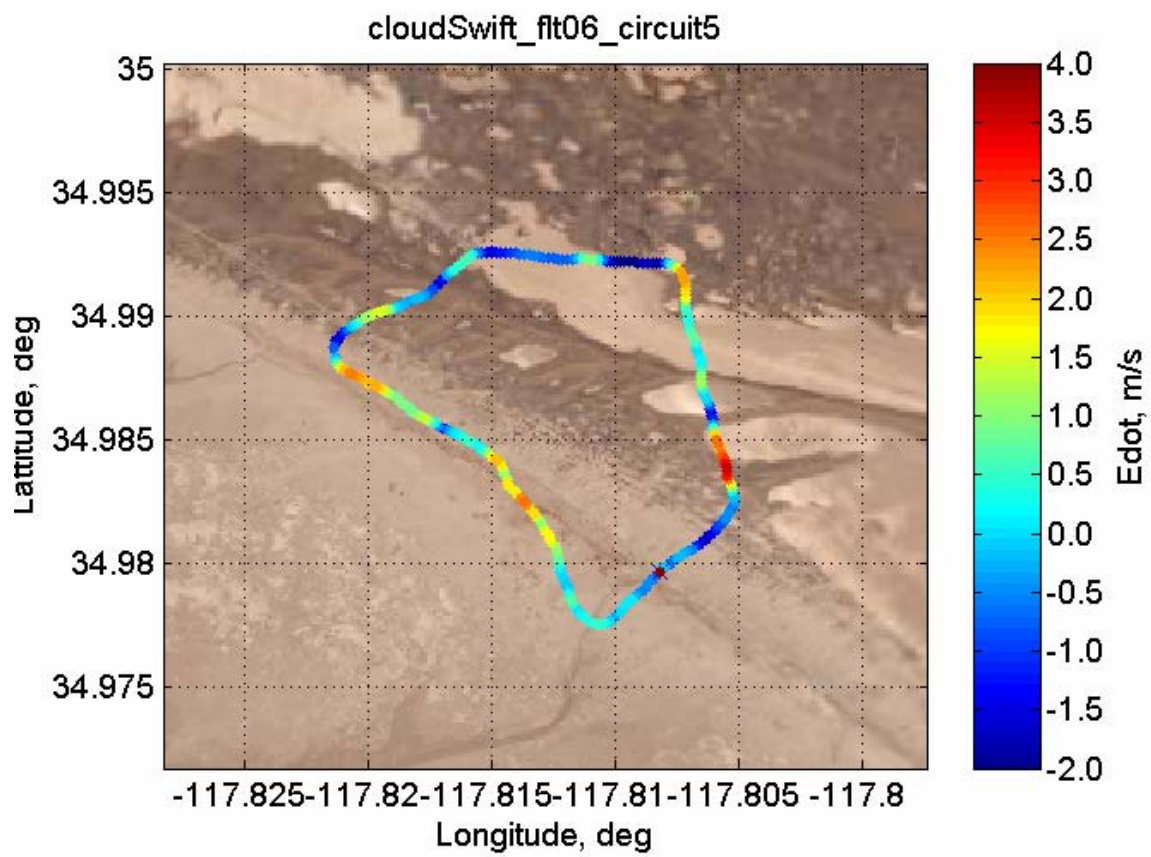


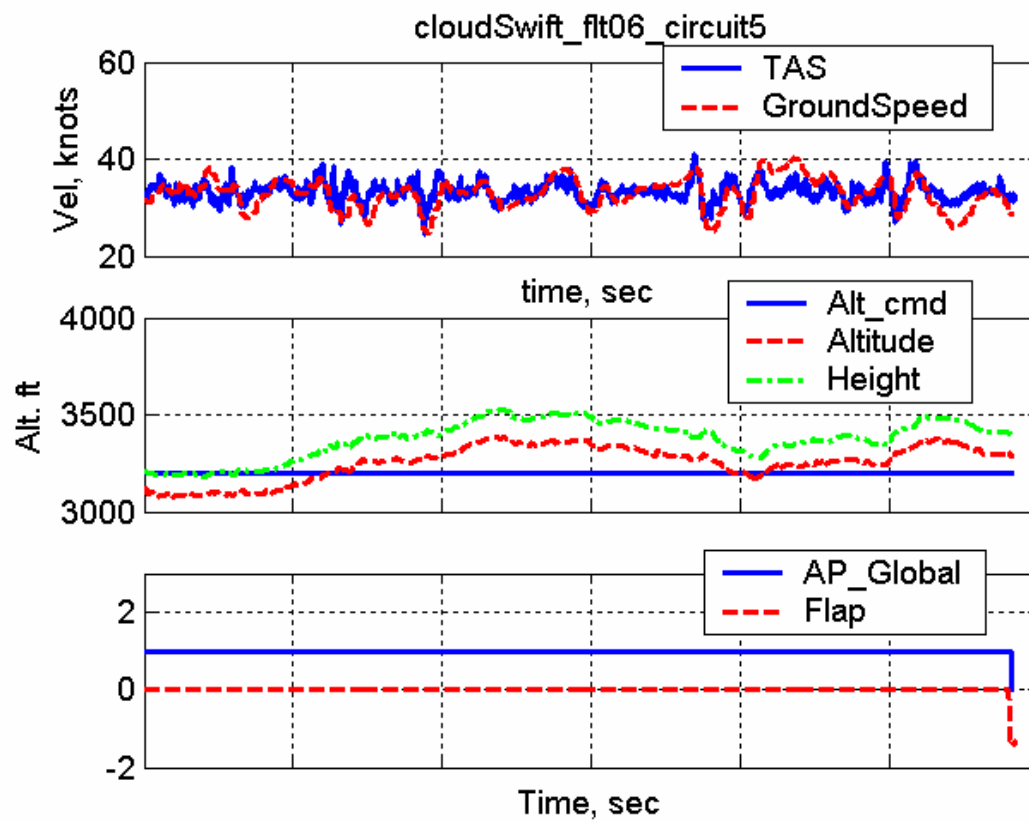
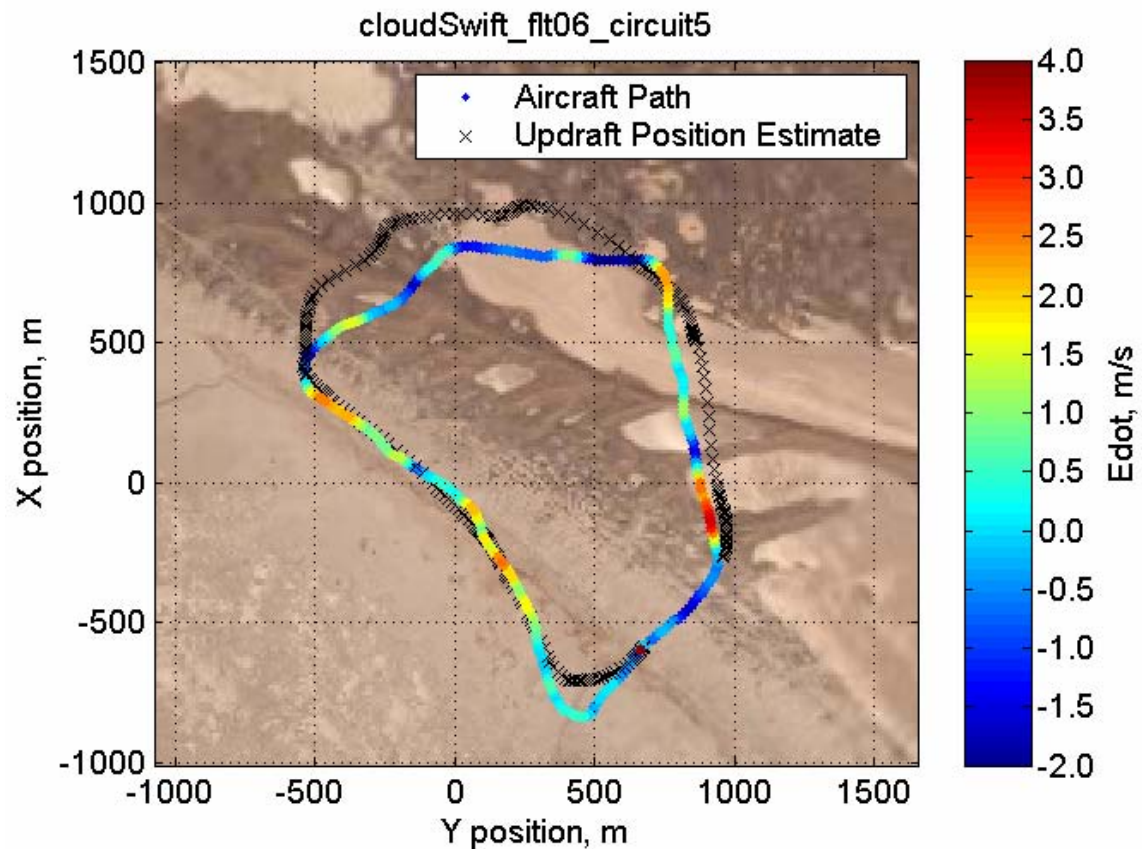


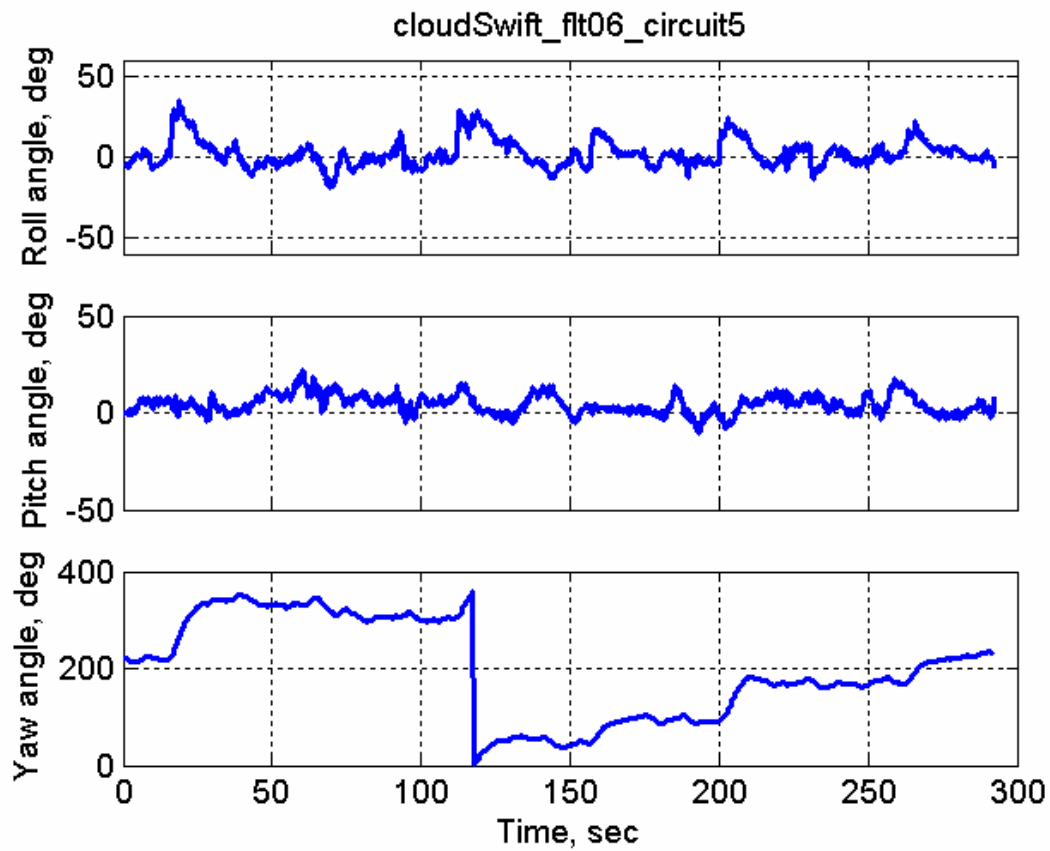
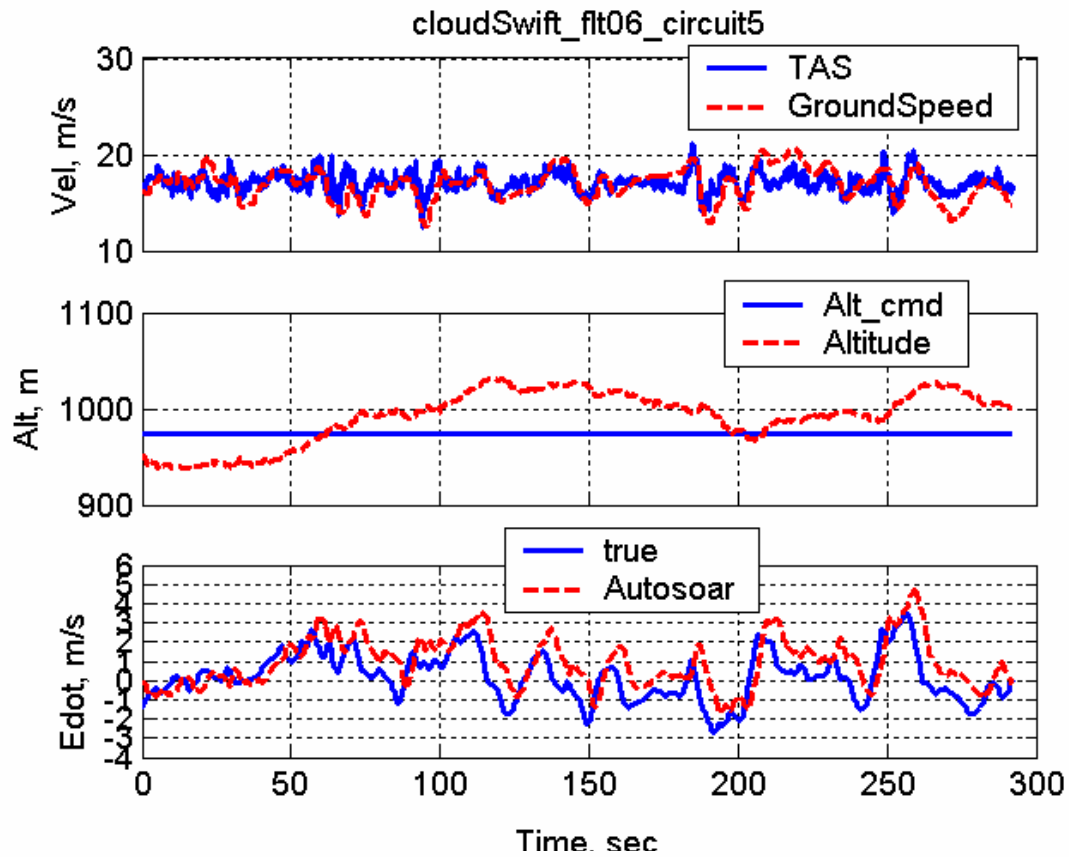
Flight 6, circuit 5

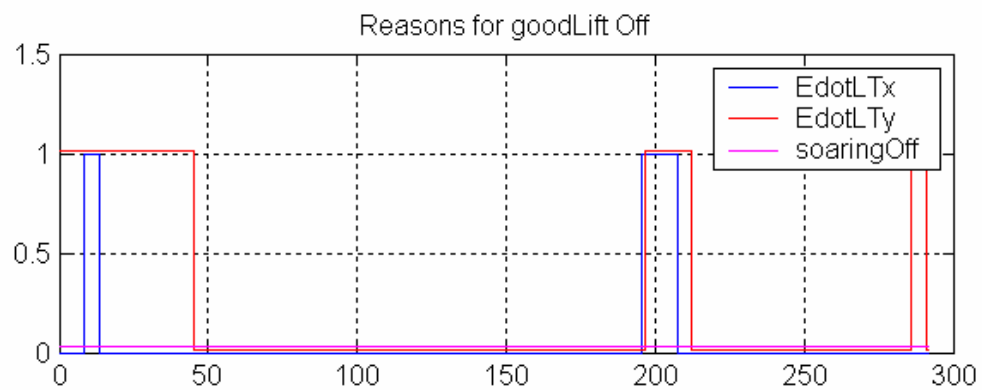
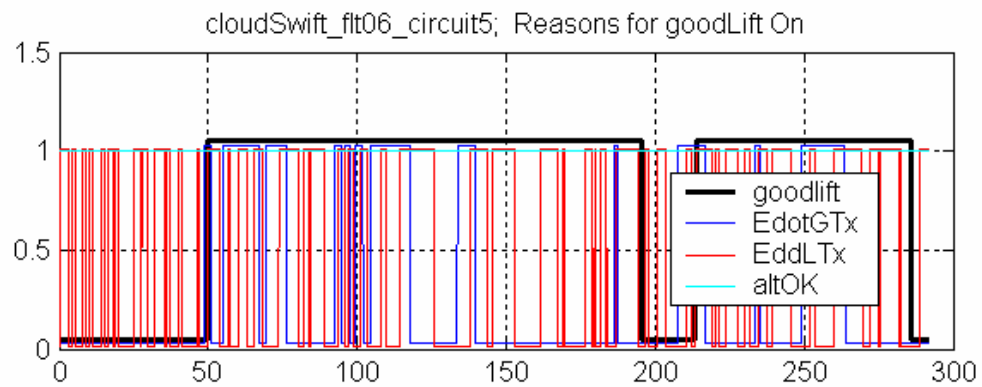
Four thermals were encountered during this circuit. Note that the aircraft climbed 300ft with the motor off during flight through these updrafts. Note the choppy nature of some of the thermals and the sink surrounding the thermals.





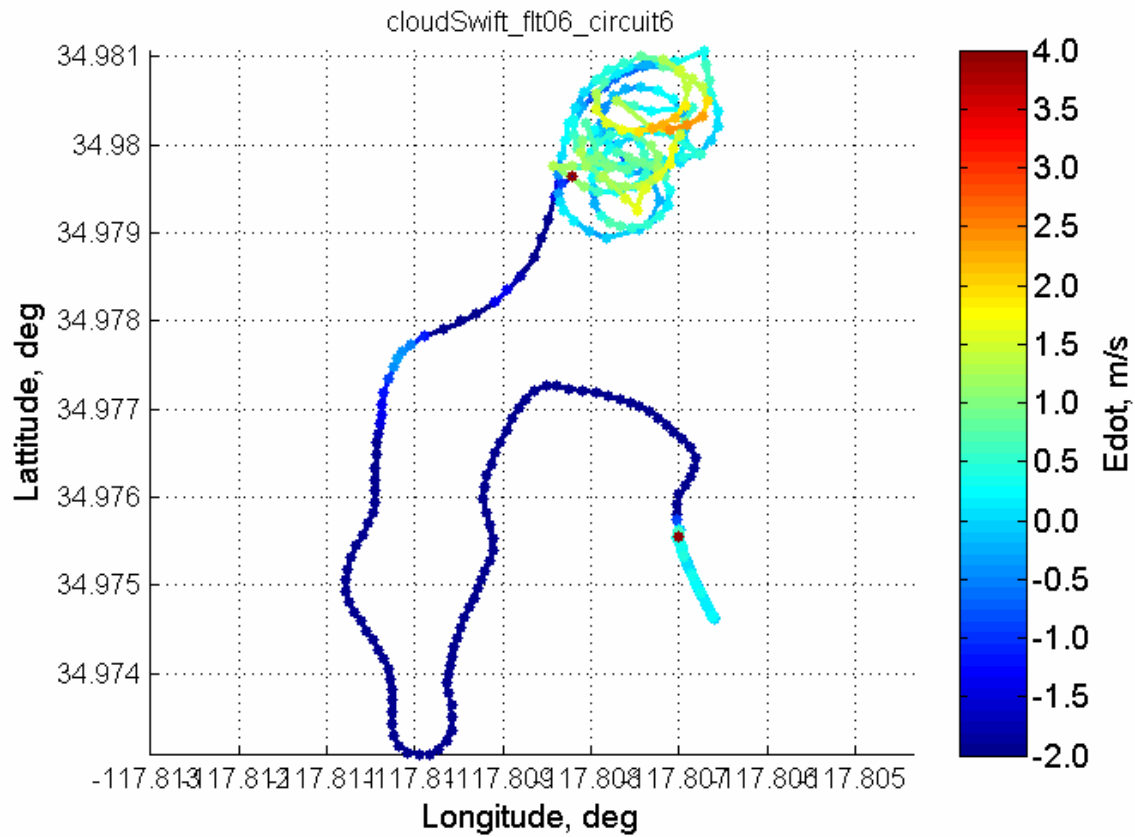


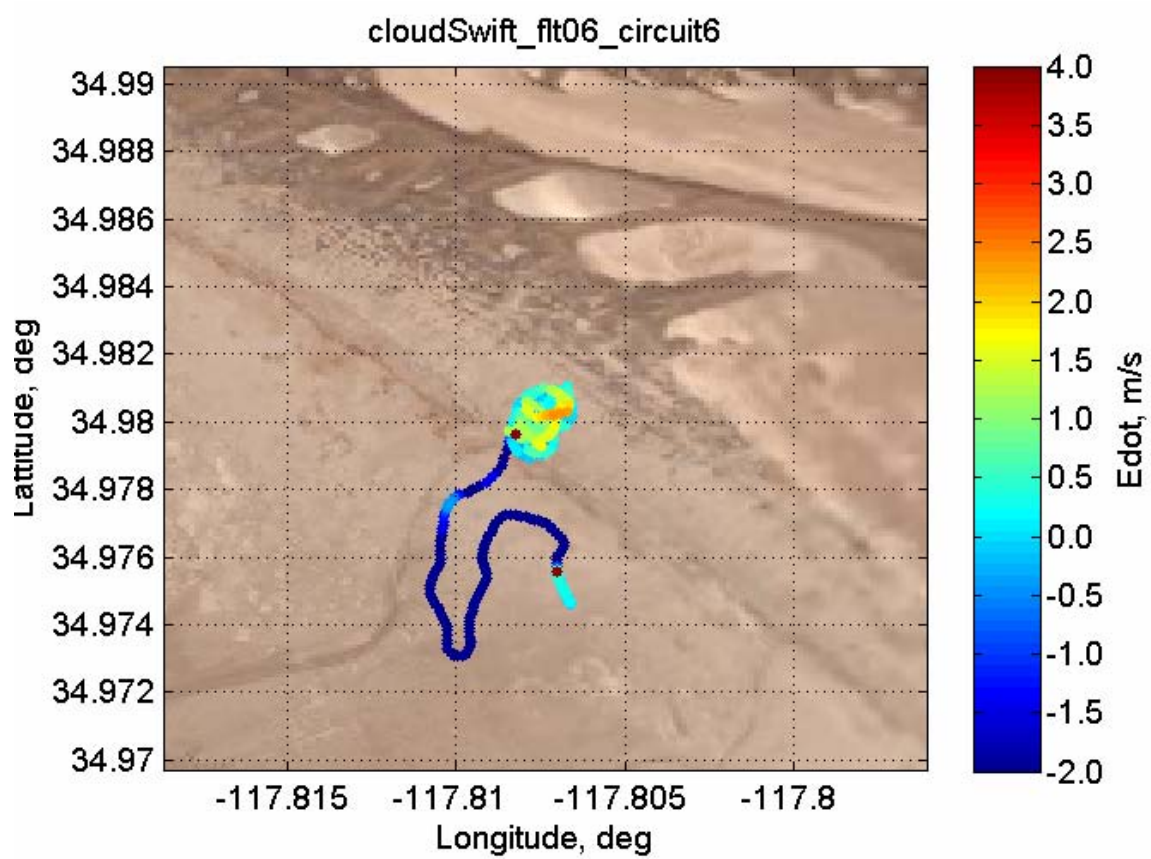


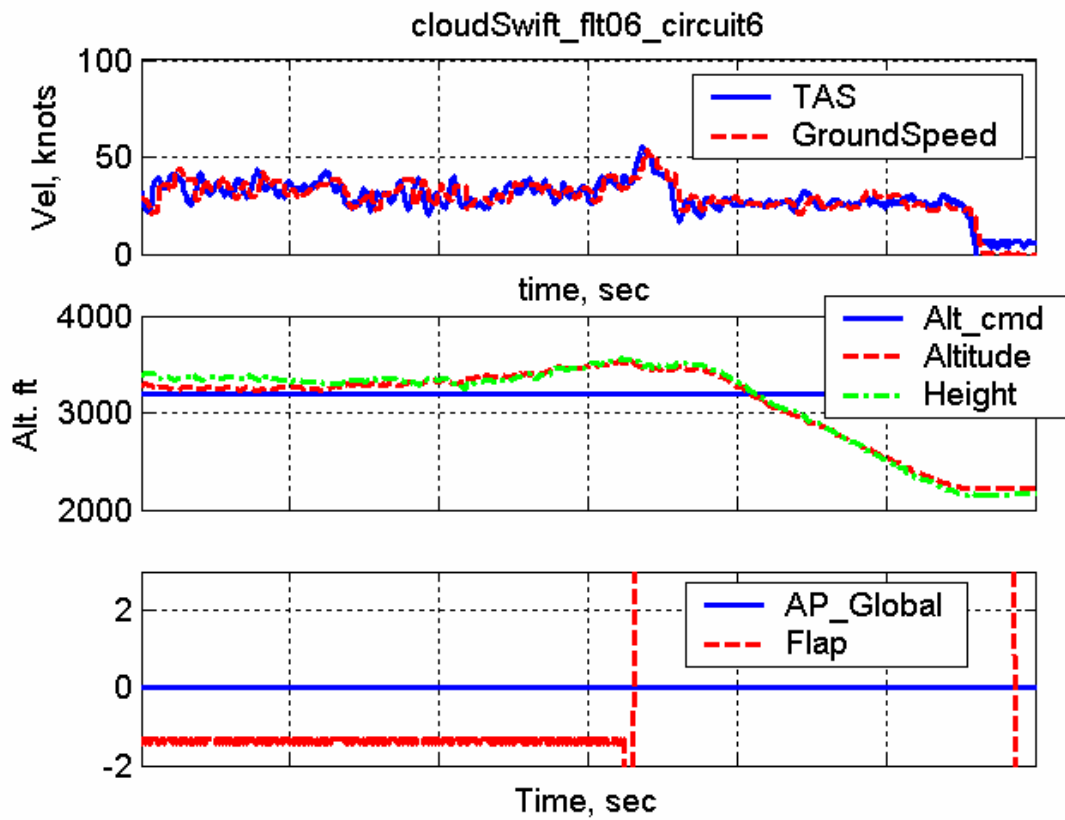
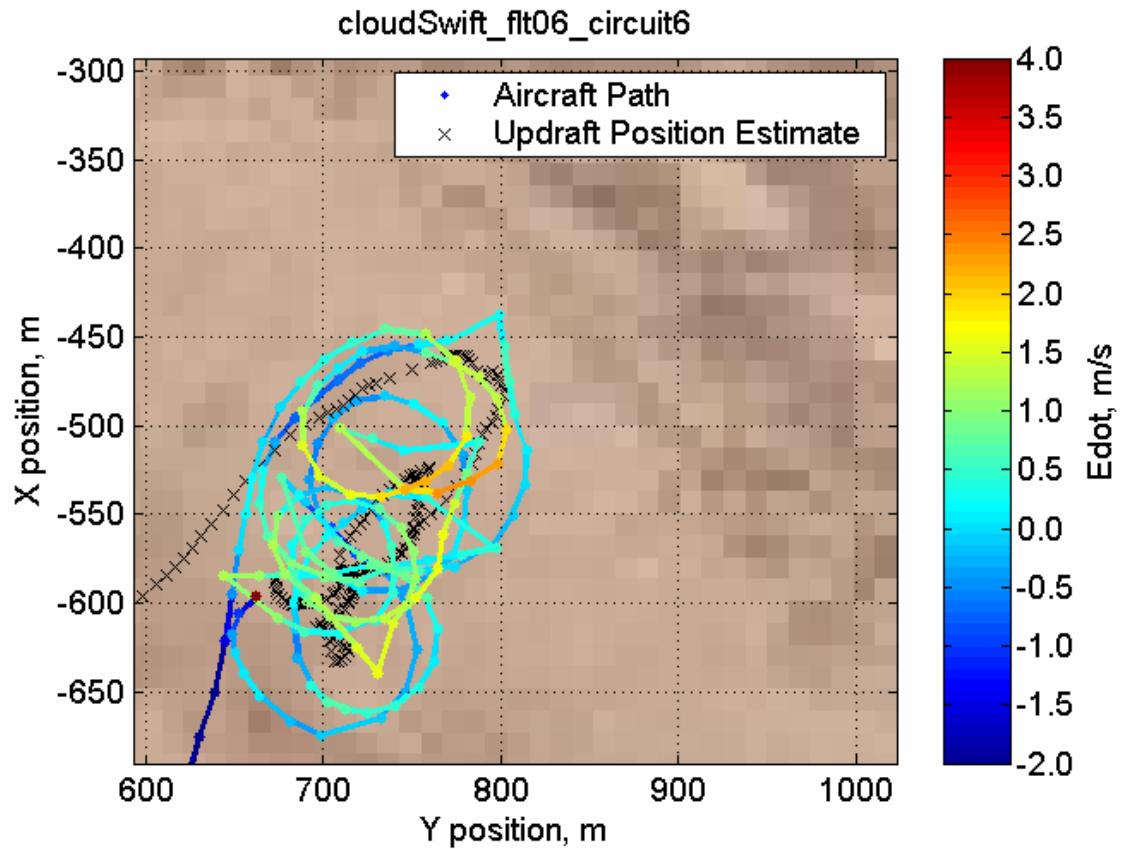


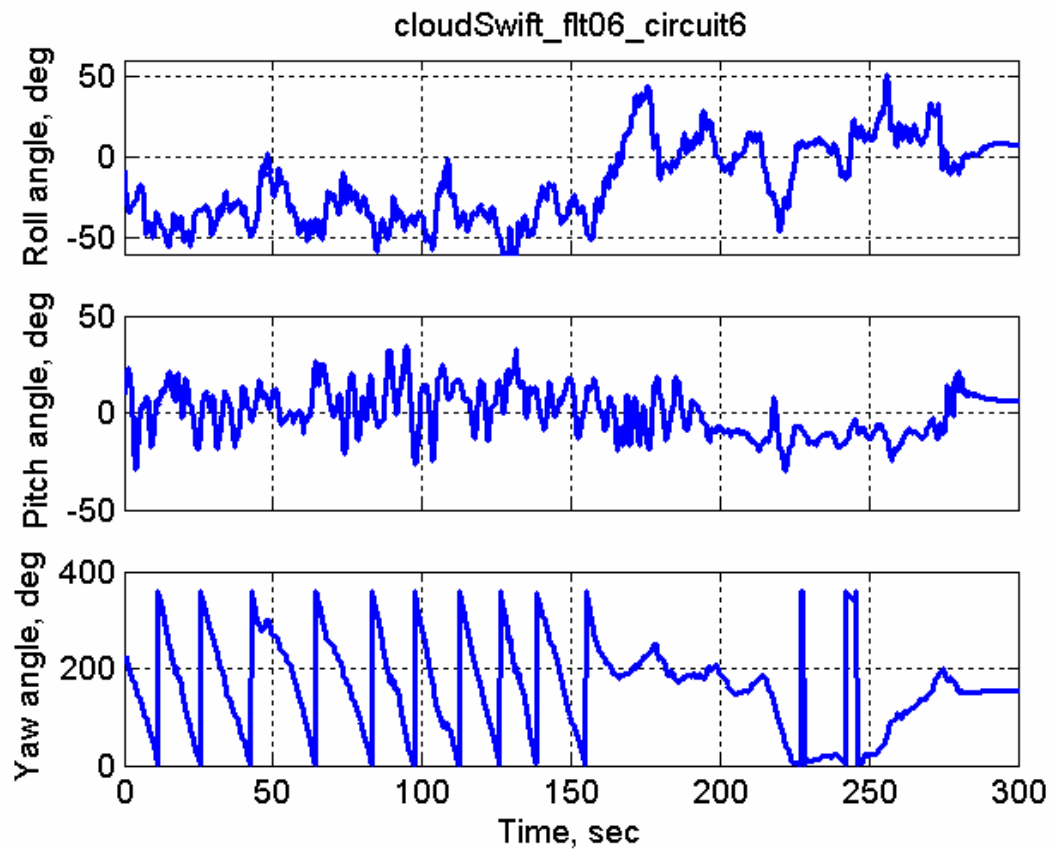
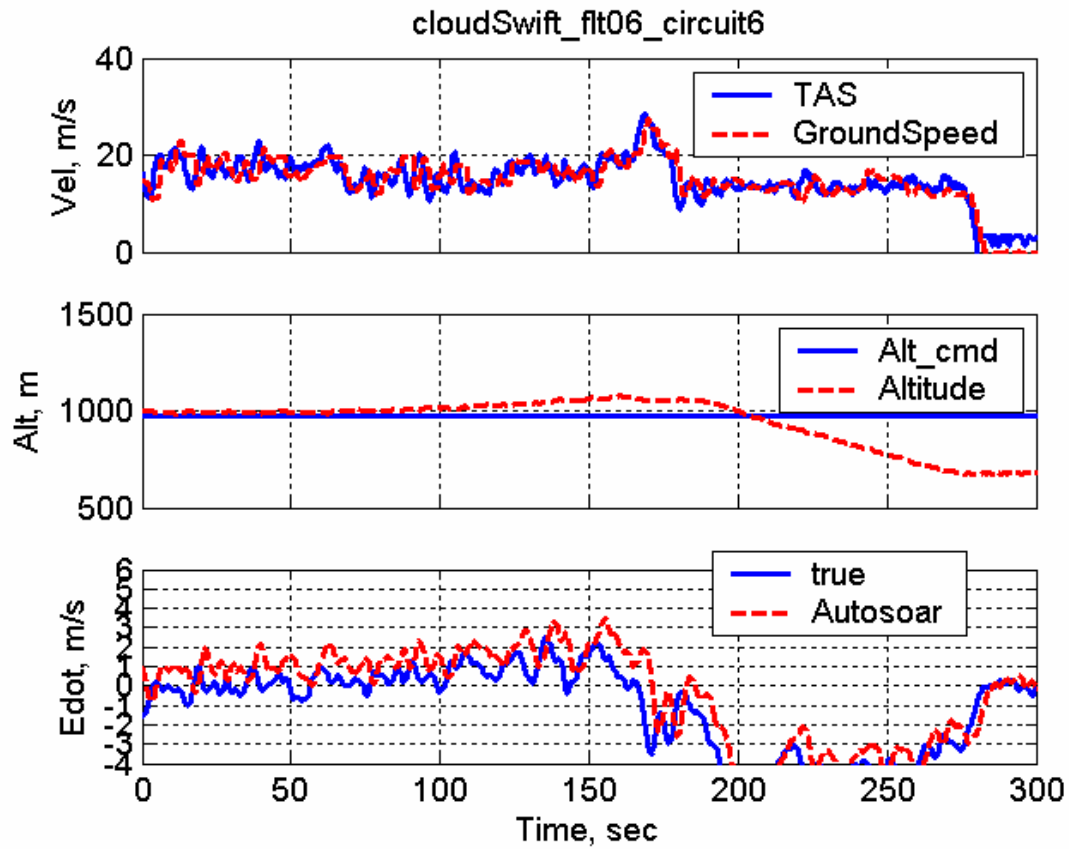
Flight 6, circuit 6

This circuit includes 1 thermal and some piloted soaring as well as the landing. All flight during this time is under pilot control. Note GPS position problems associated with high bank angle.





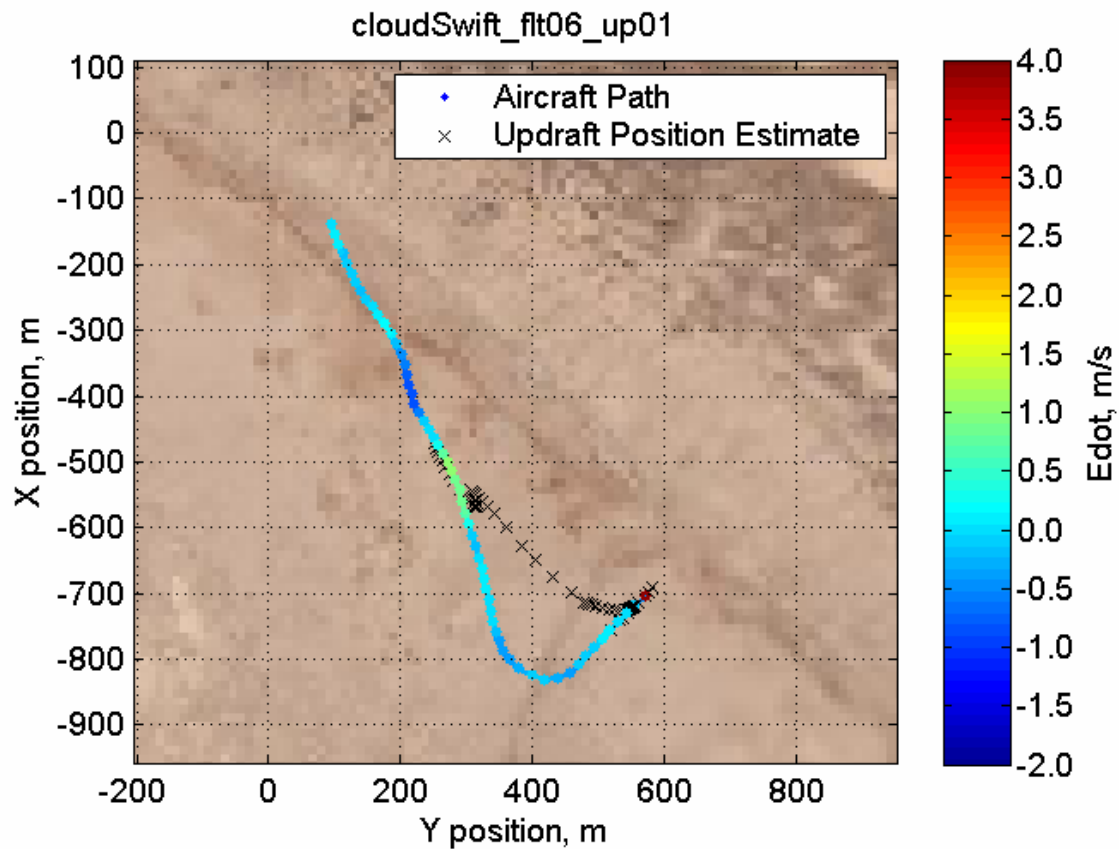


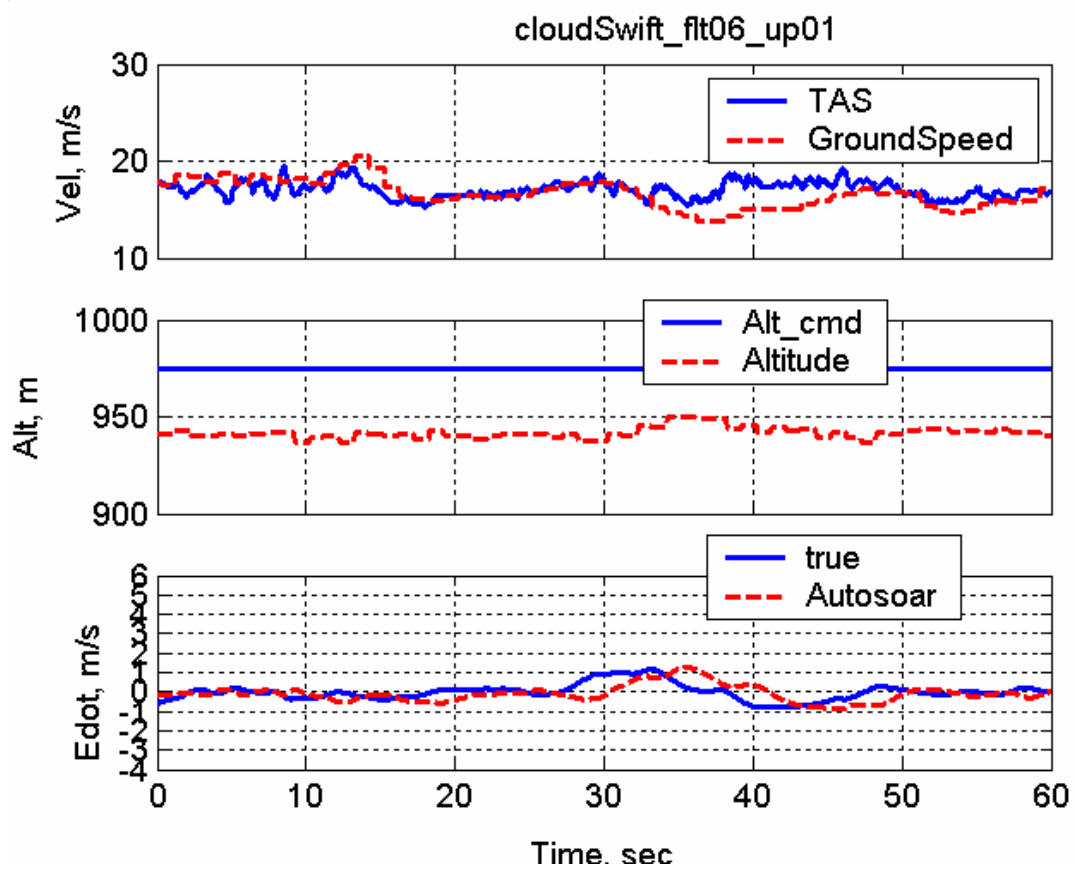


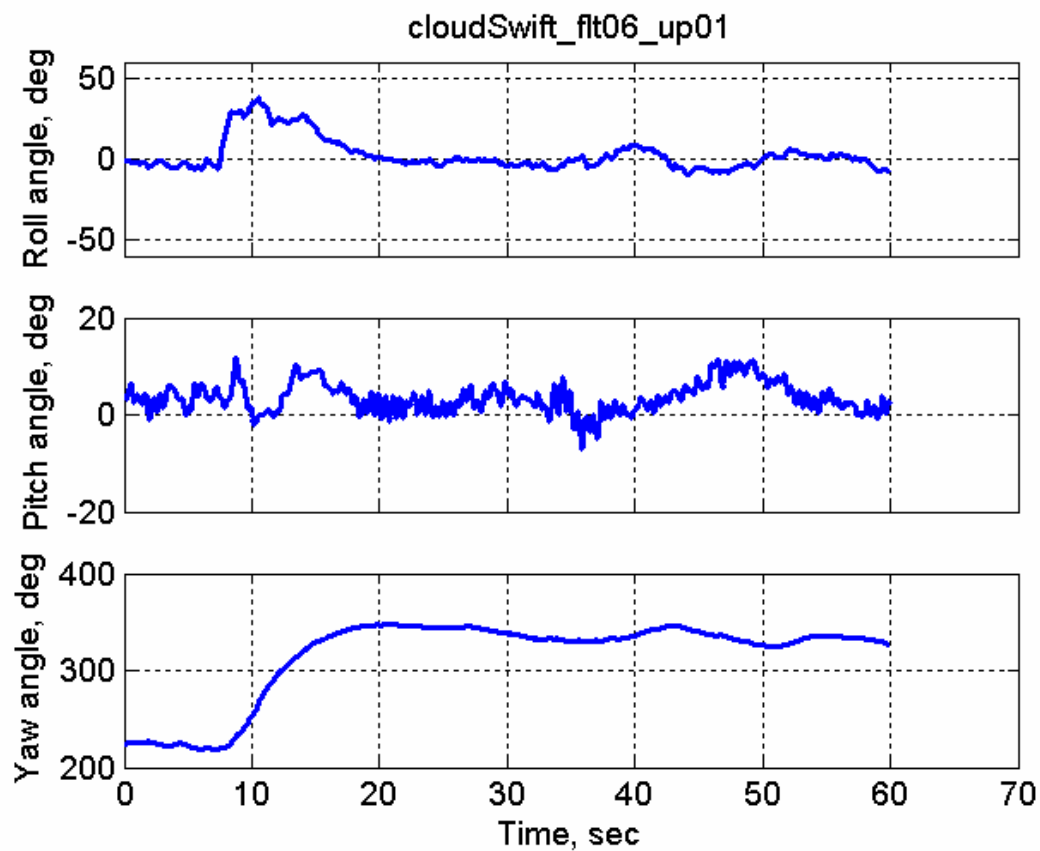
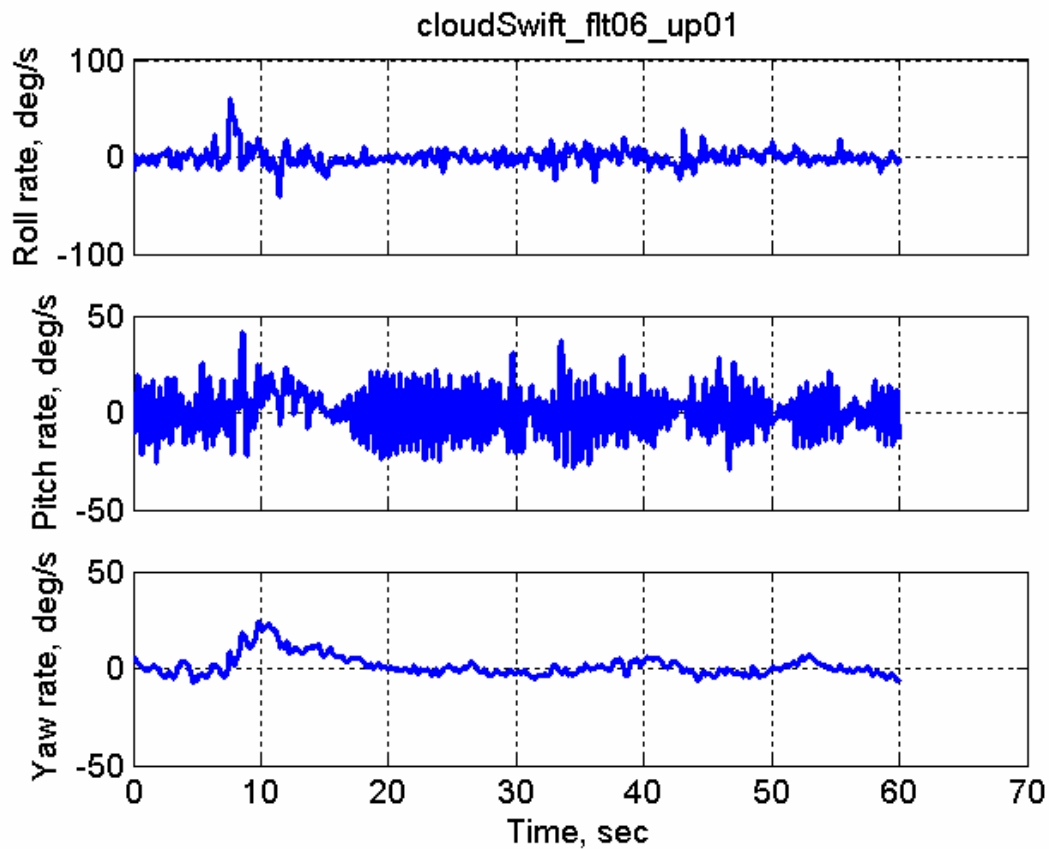


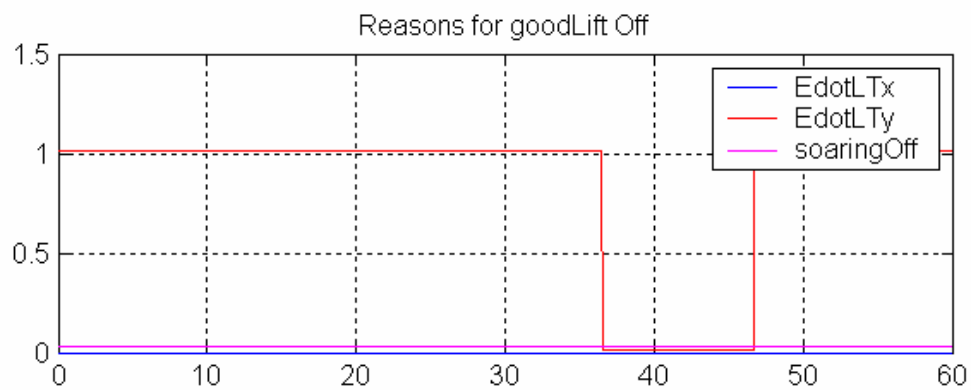
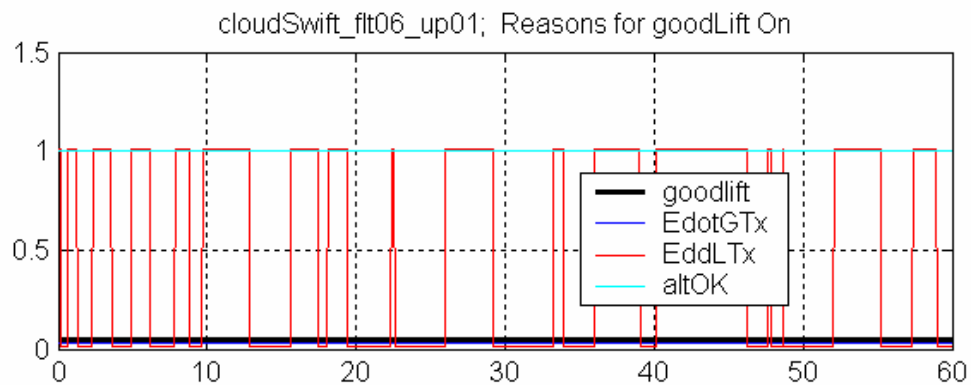
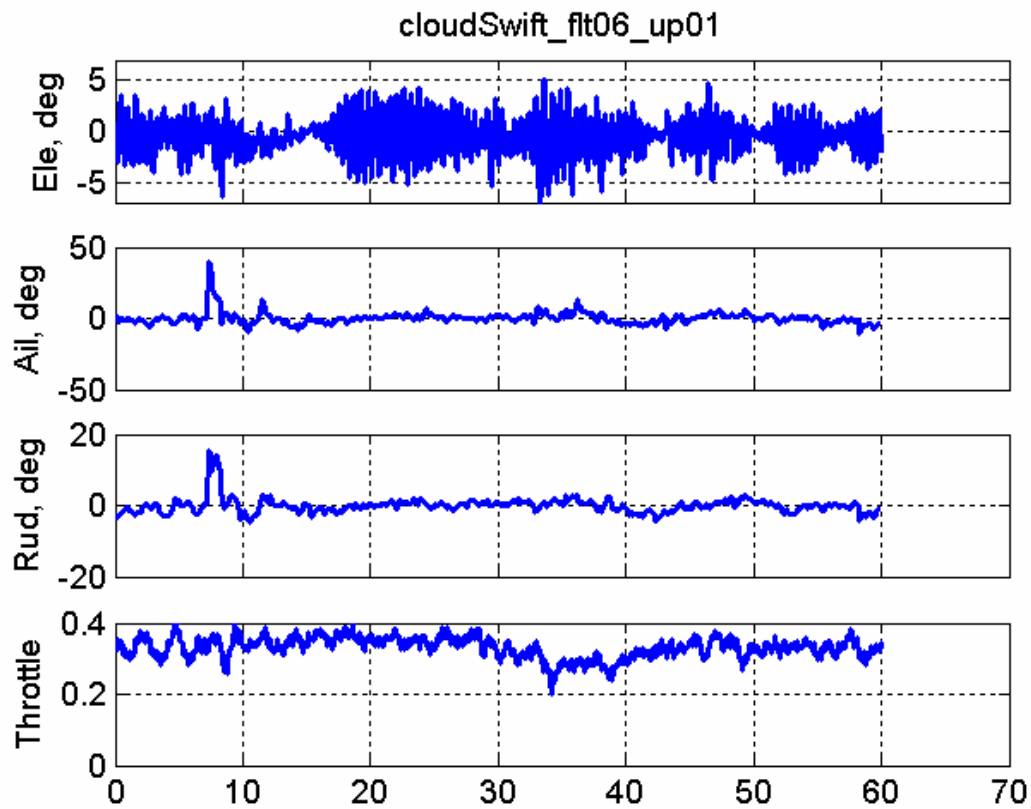
Flight 6, updraft 1

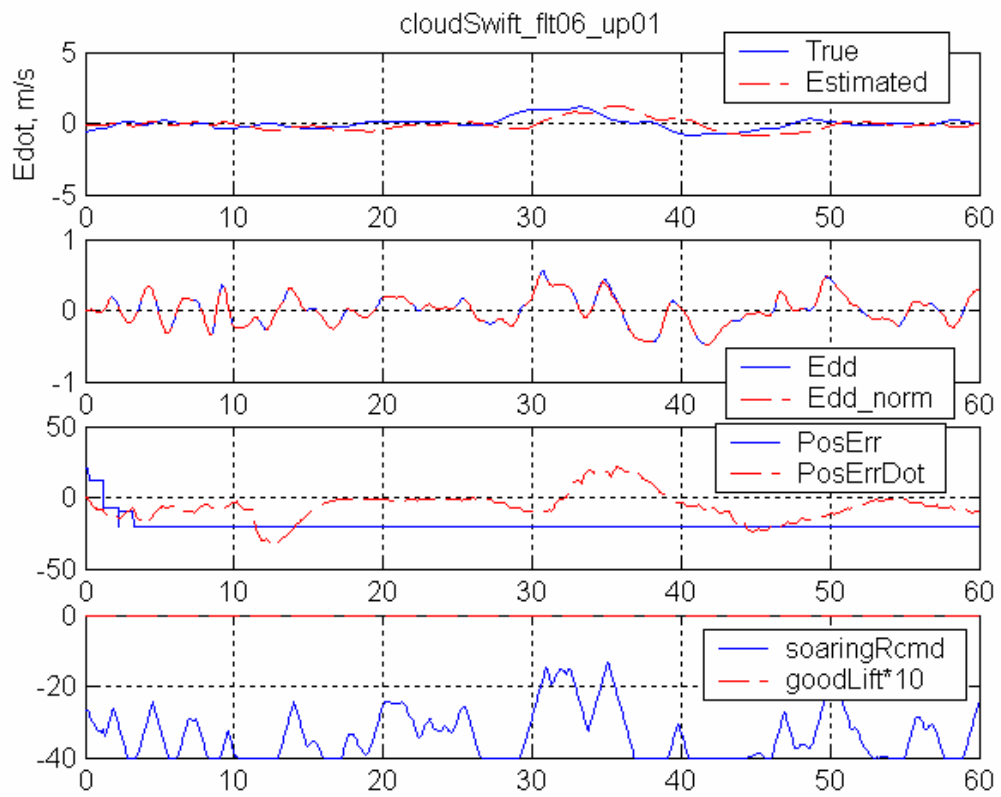
This is the first thermal encountered after the aircraft was engaged in autonomous mode. The thermal is weak and gradual. Note the nearly 2 second delay in the onboard estimation of E_{dot} . Also note the poor pitch damping with these gains. This thermal is not considered strong enough to trigger the mode logic of software version 6_52.



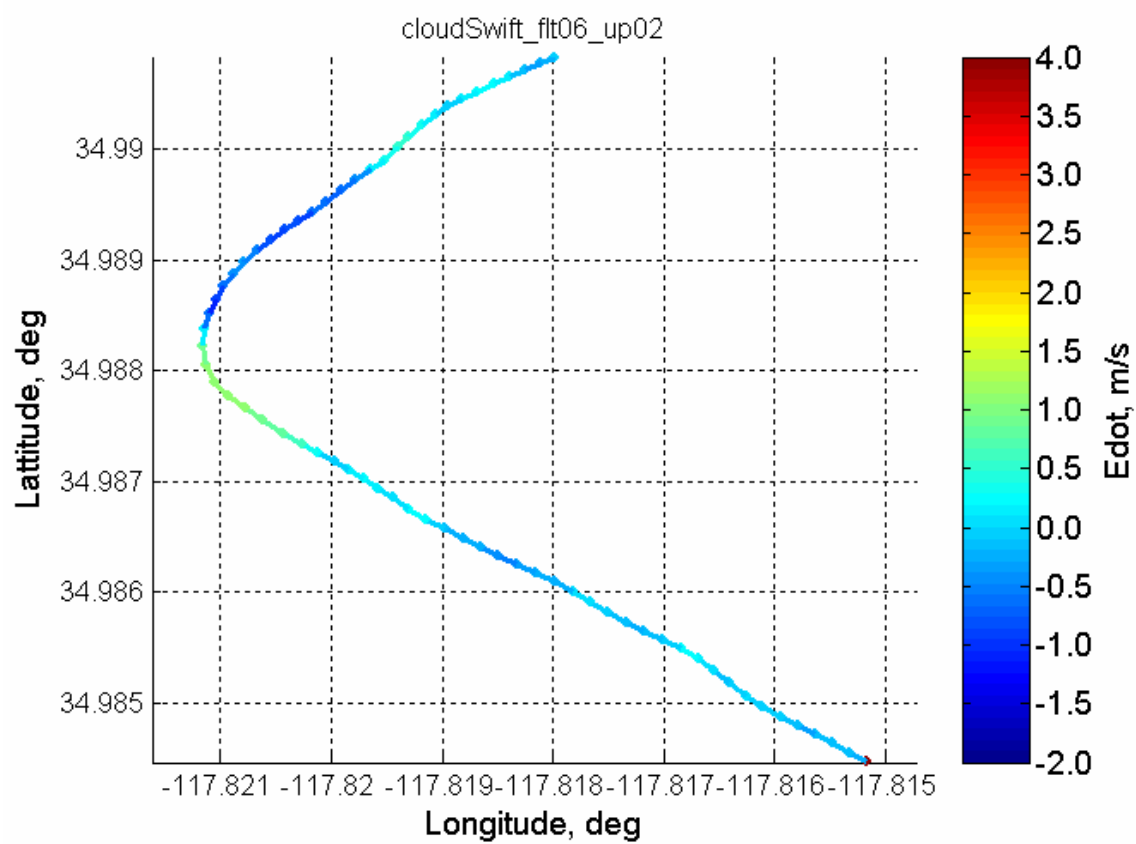


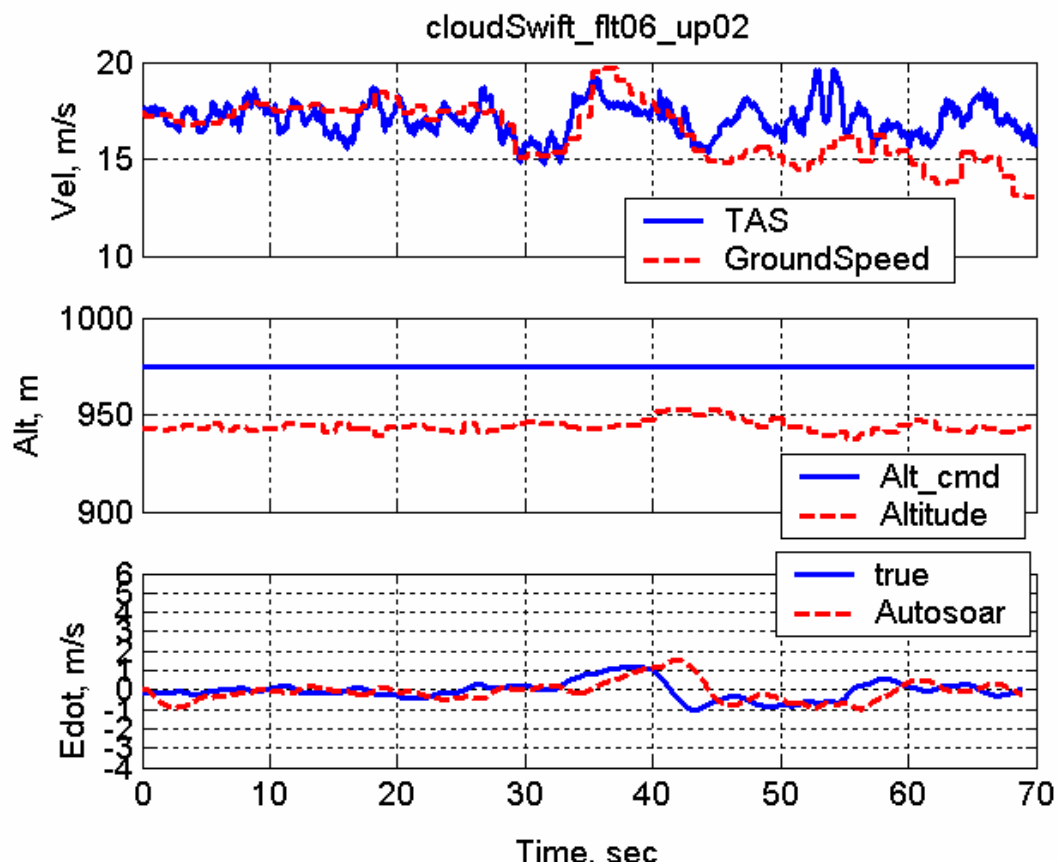
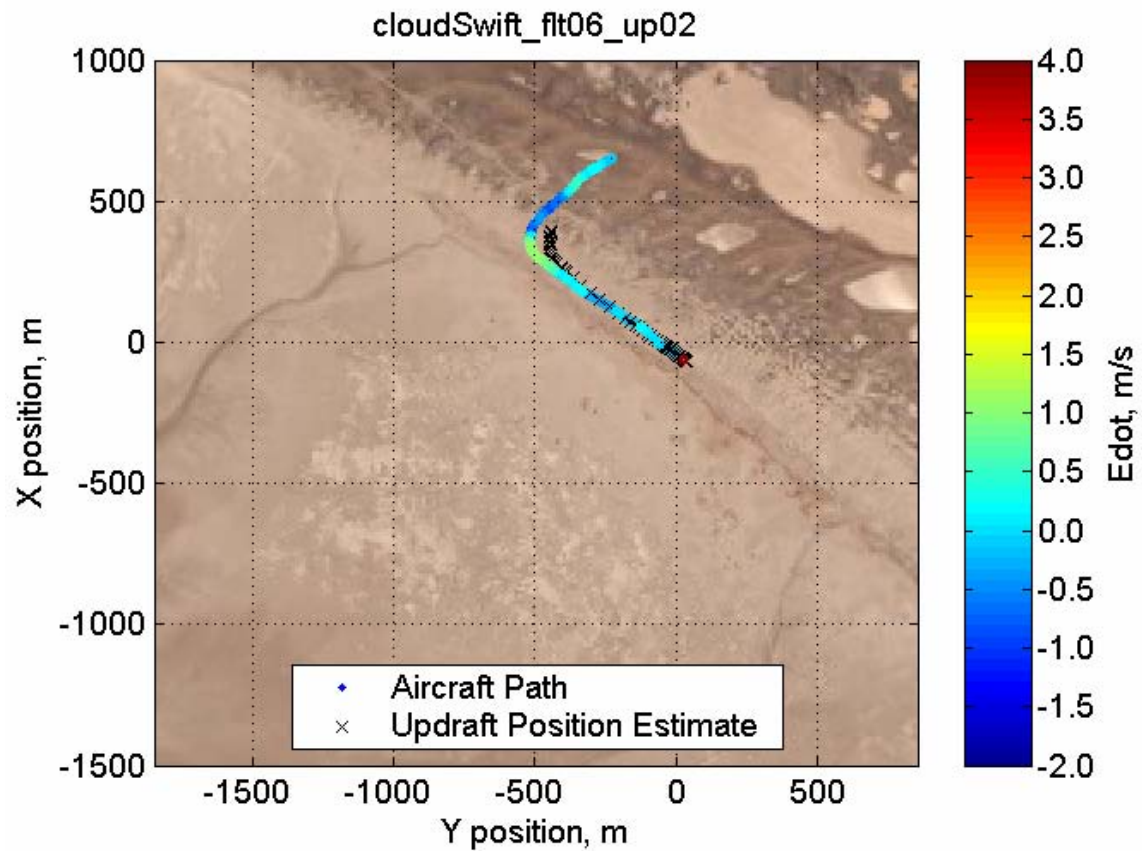


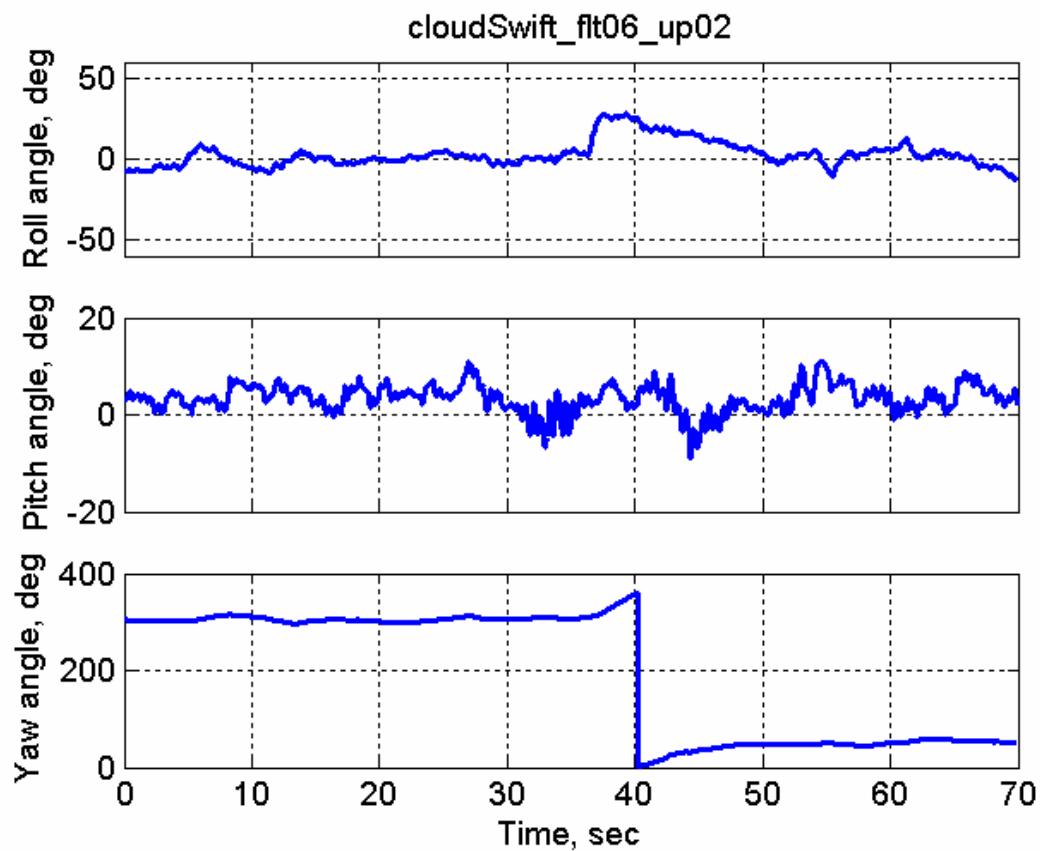
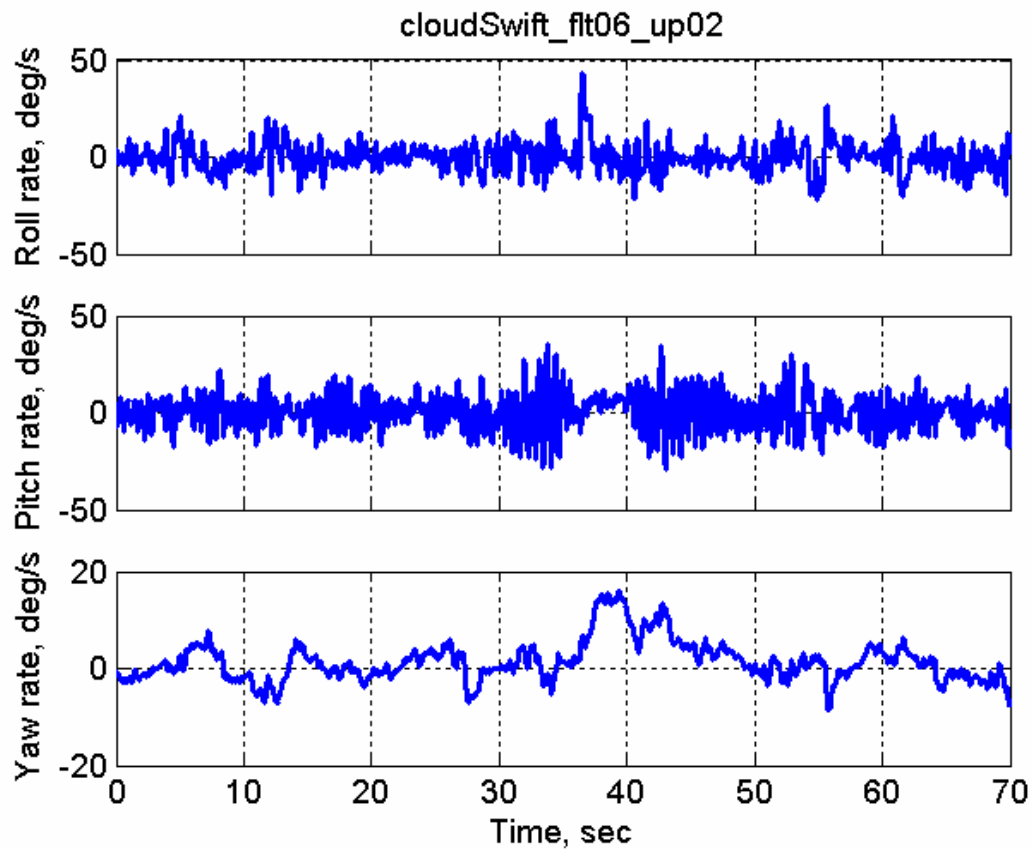


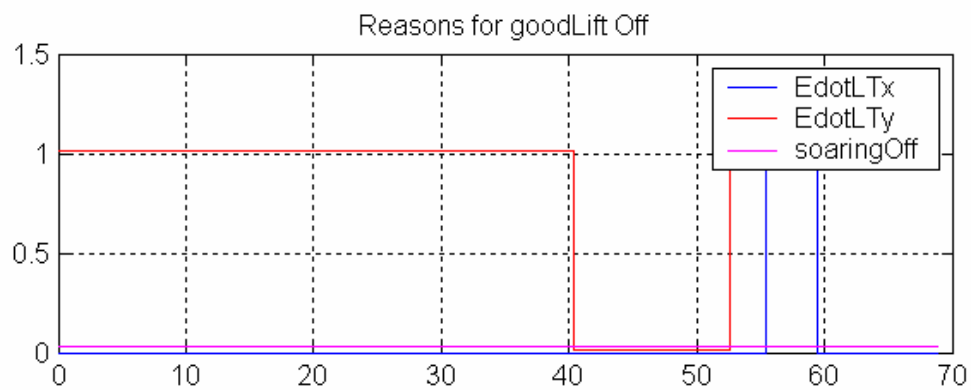
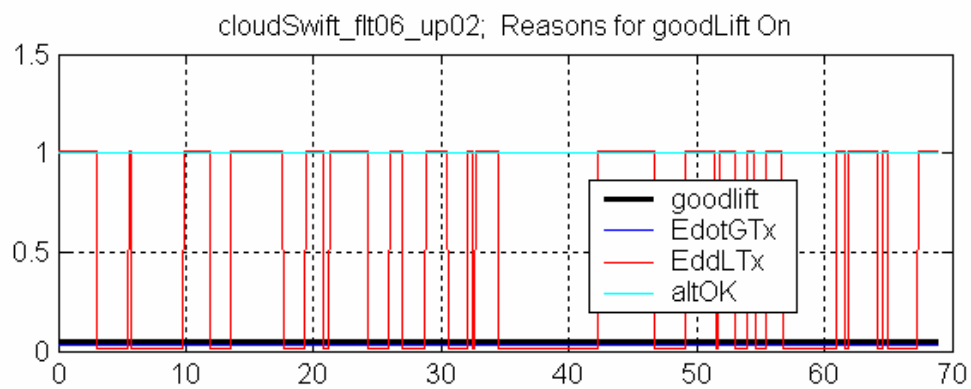
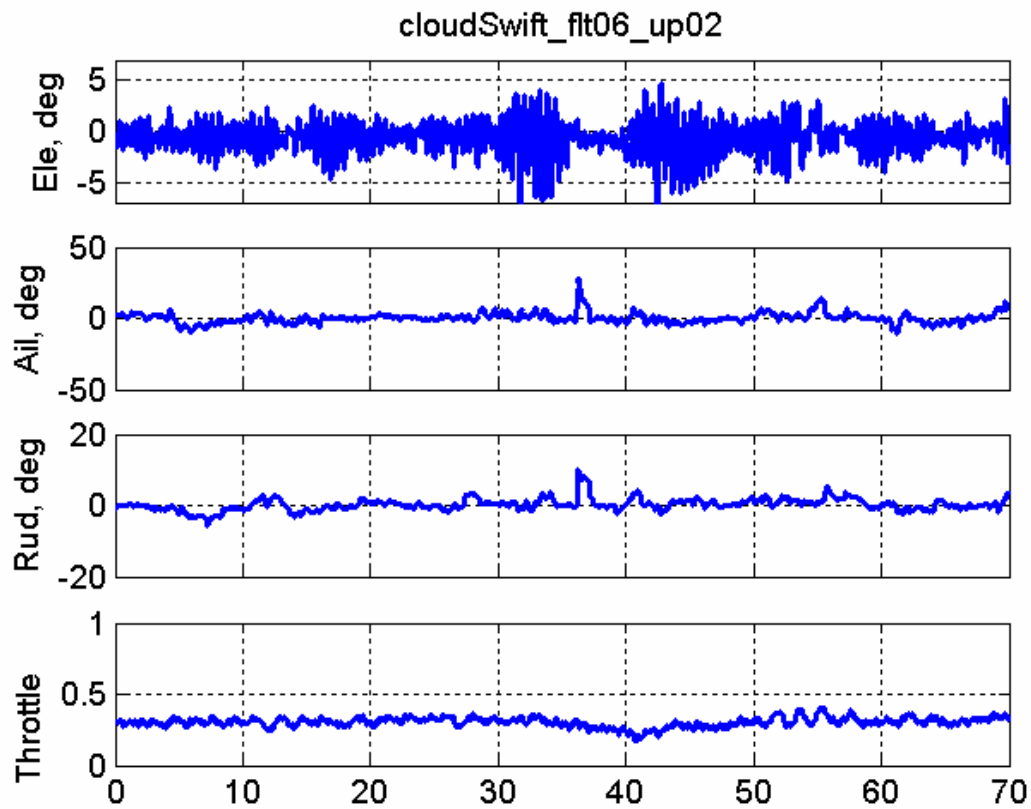


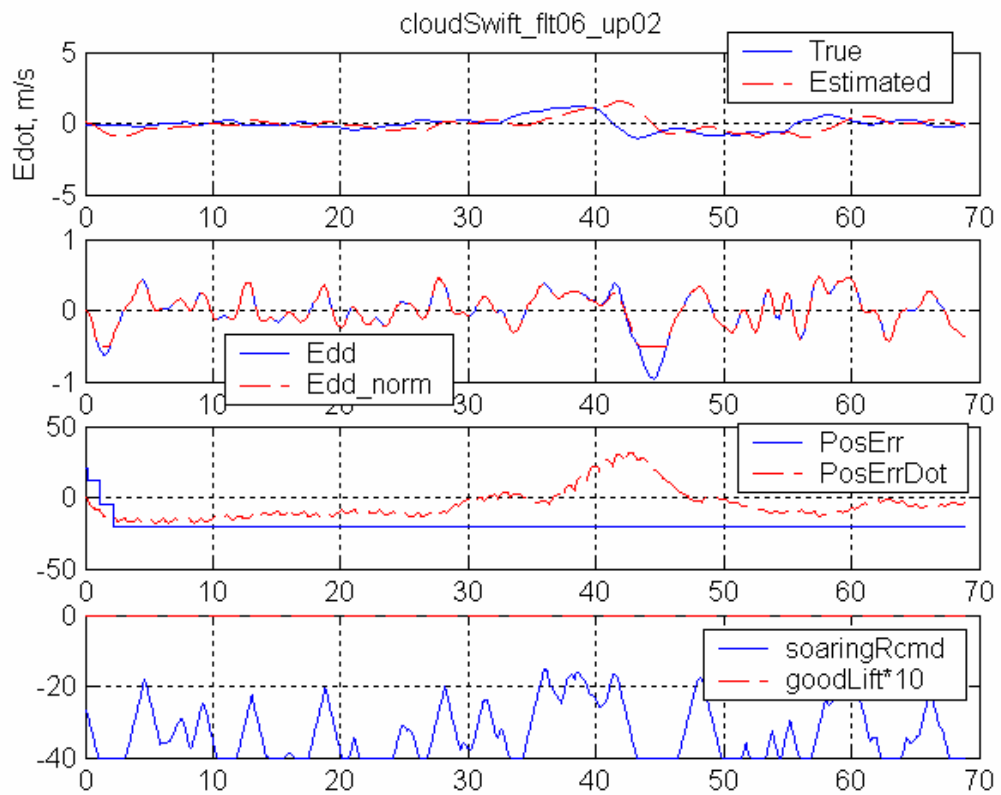
Flight 6, updraft 2



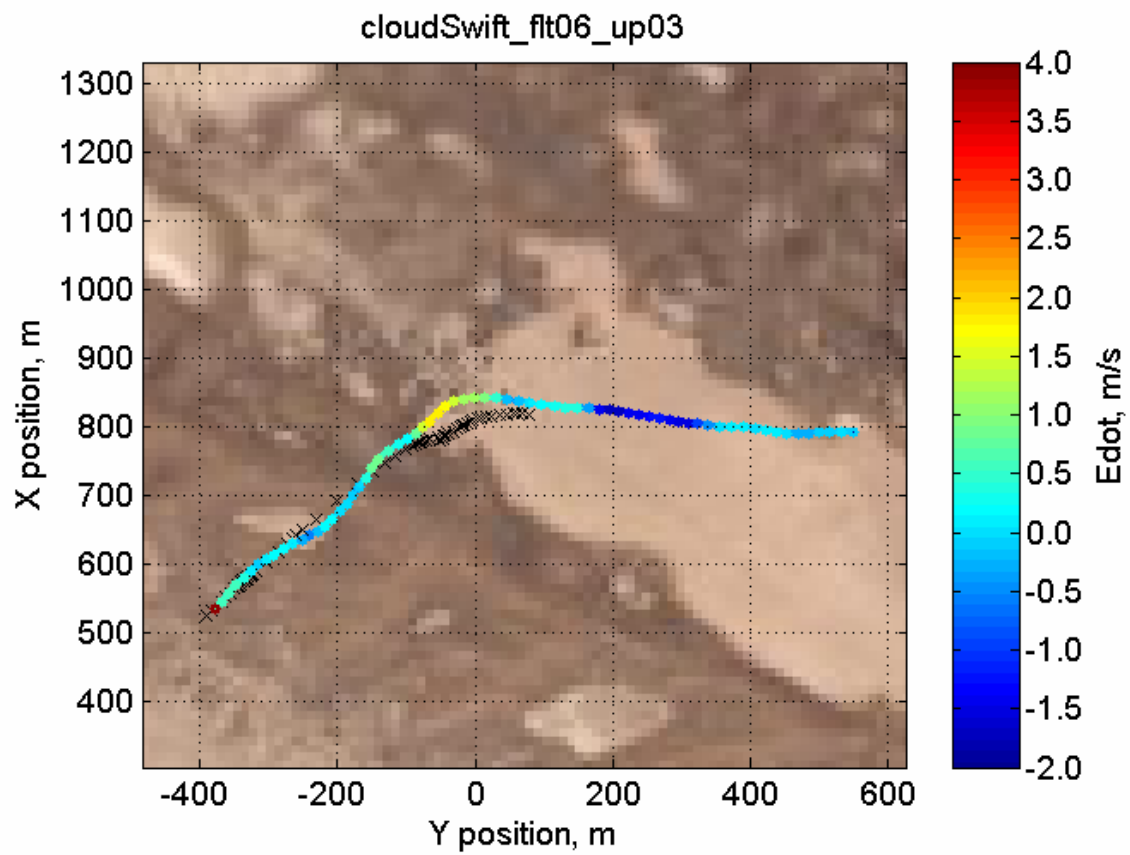


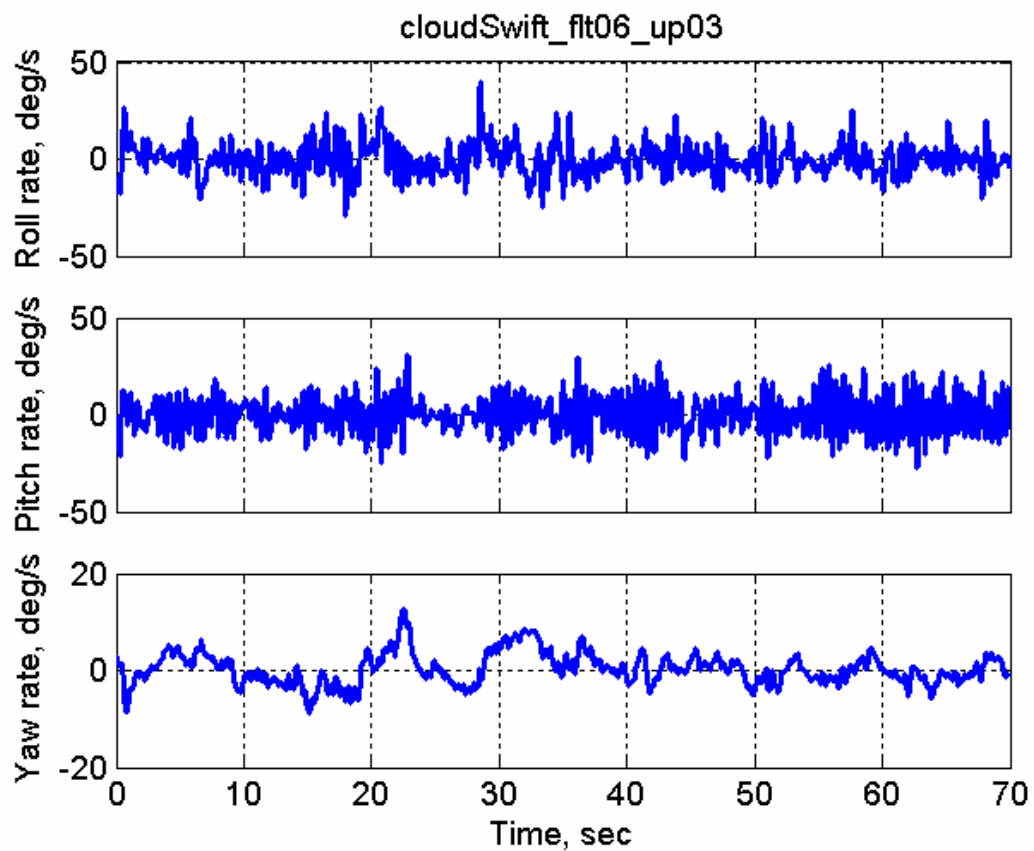
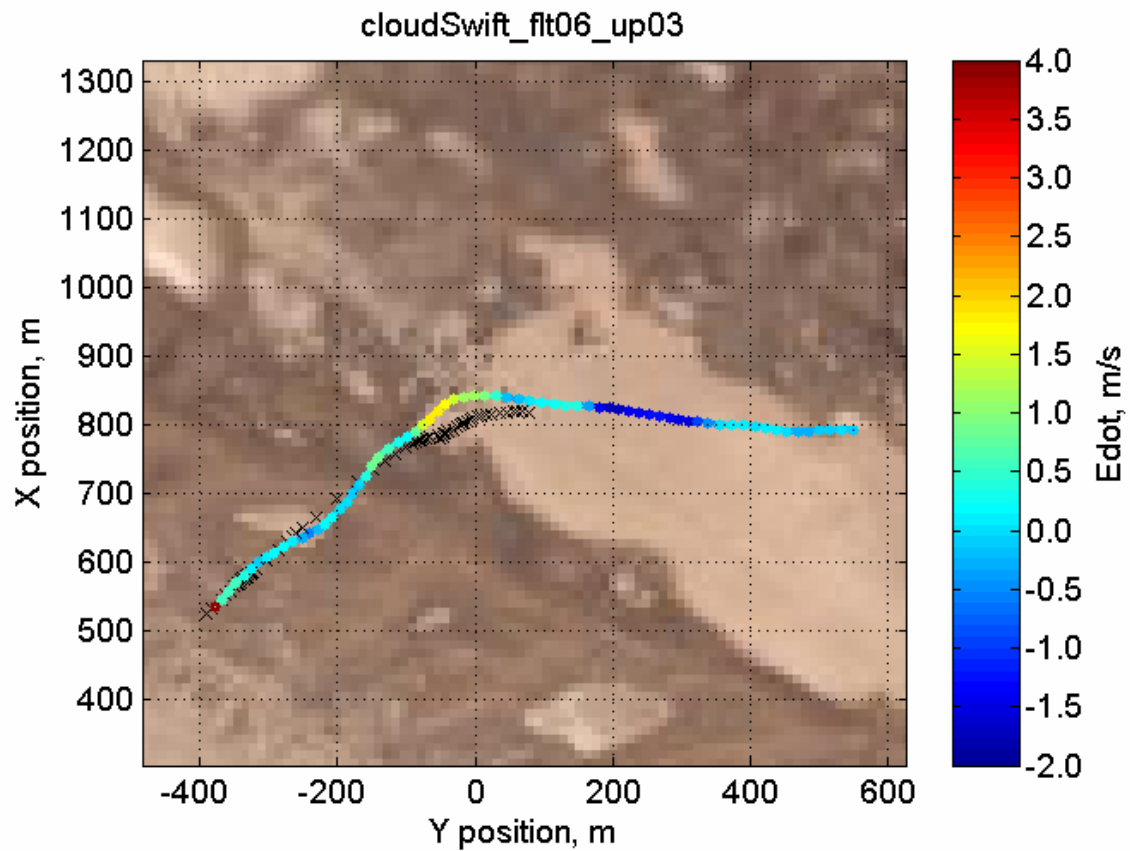


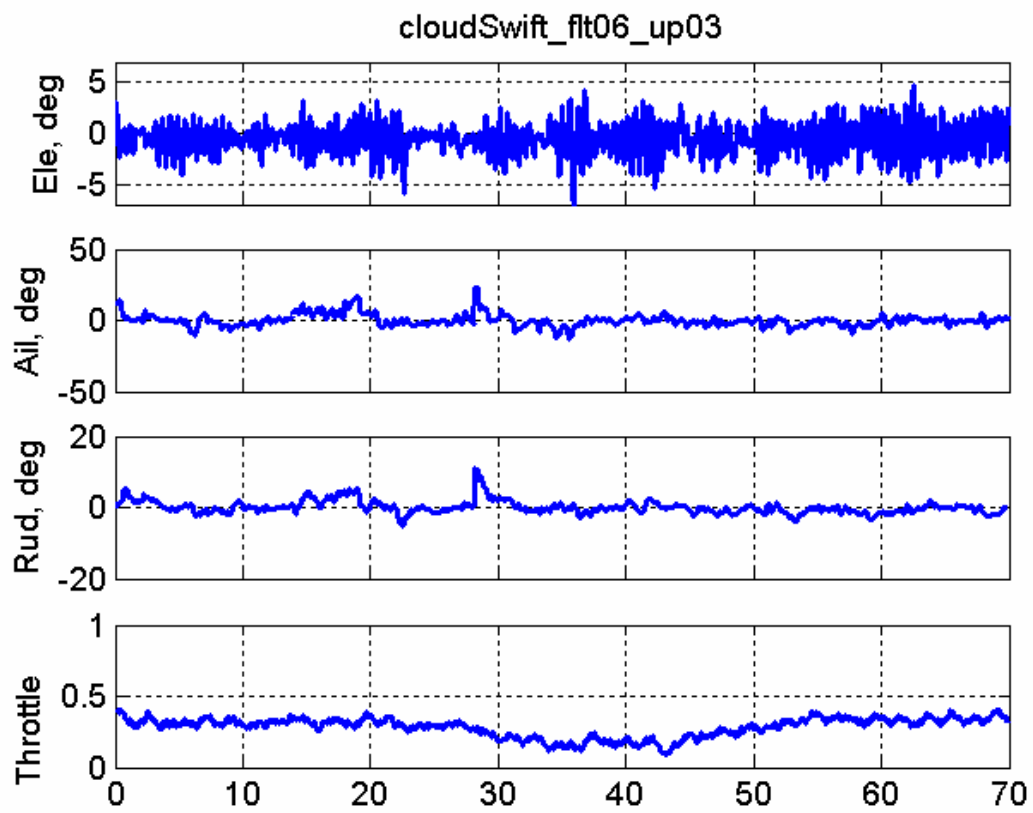
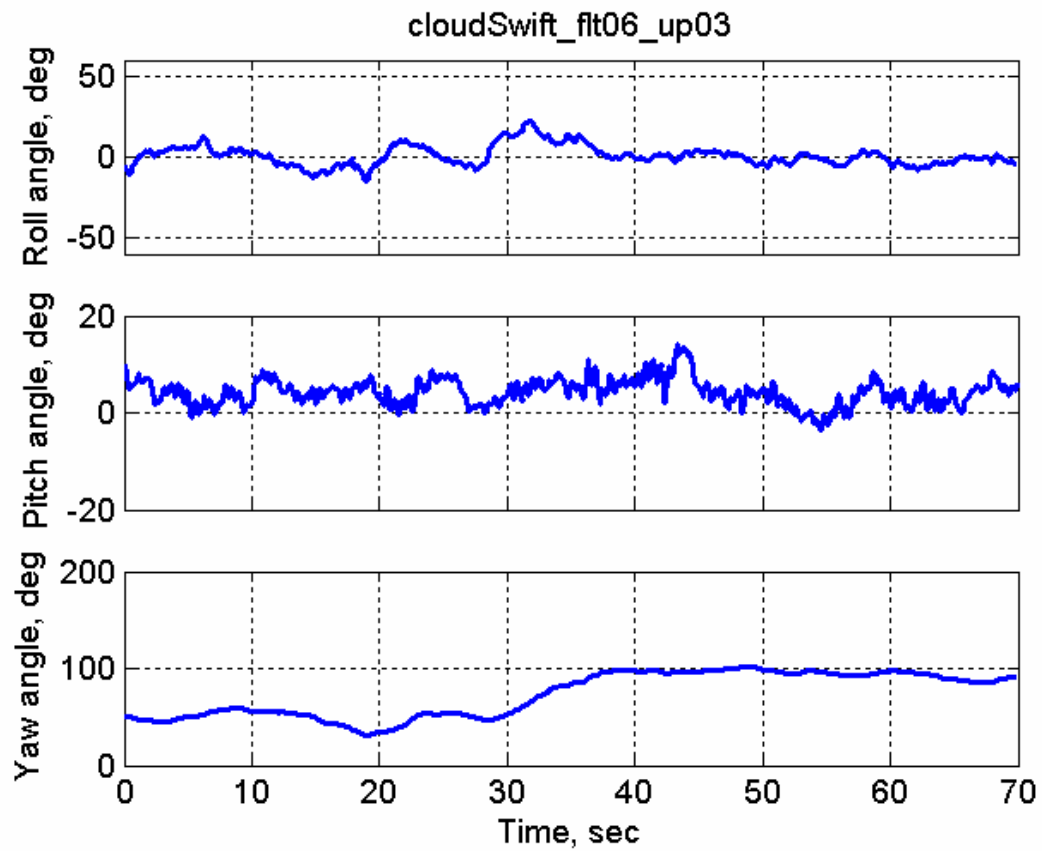


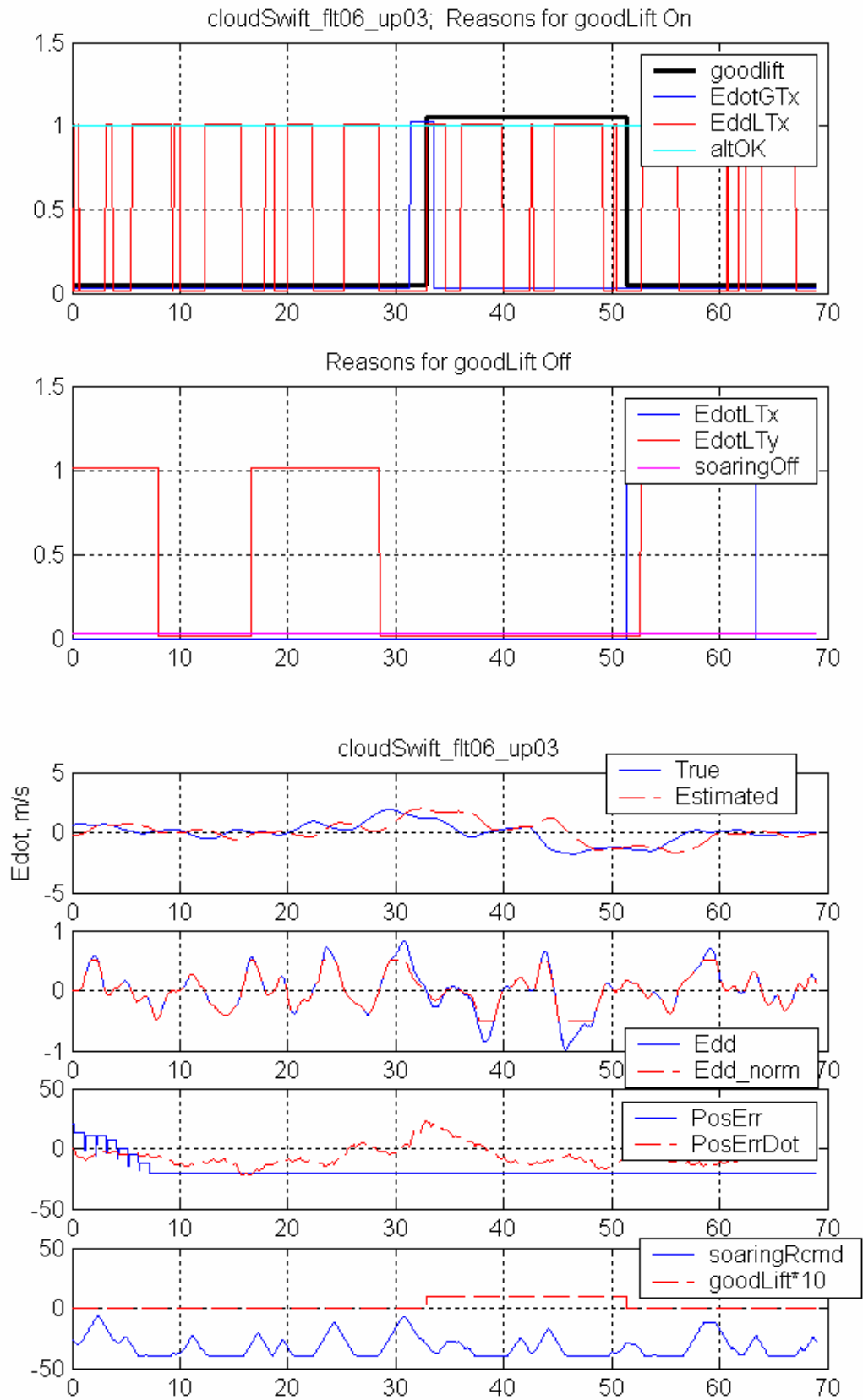


Flight 6, updraft 3

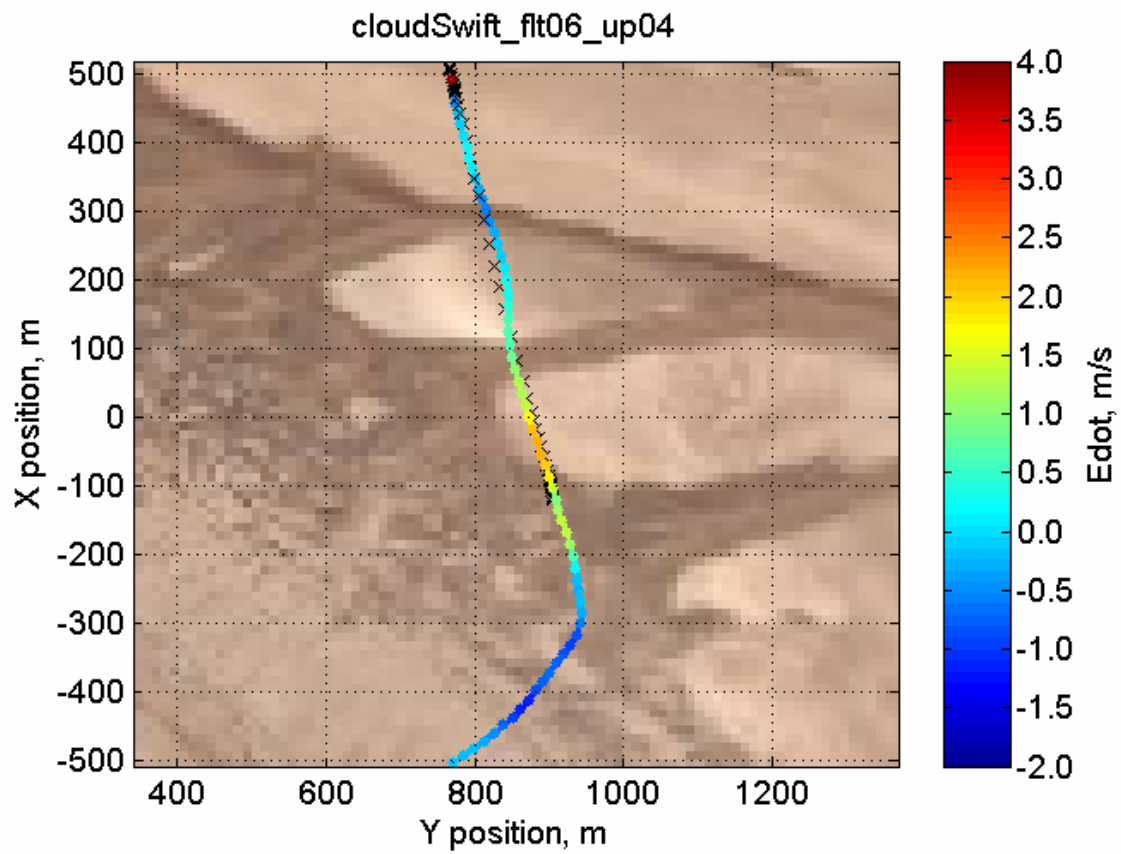


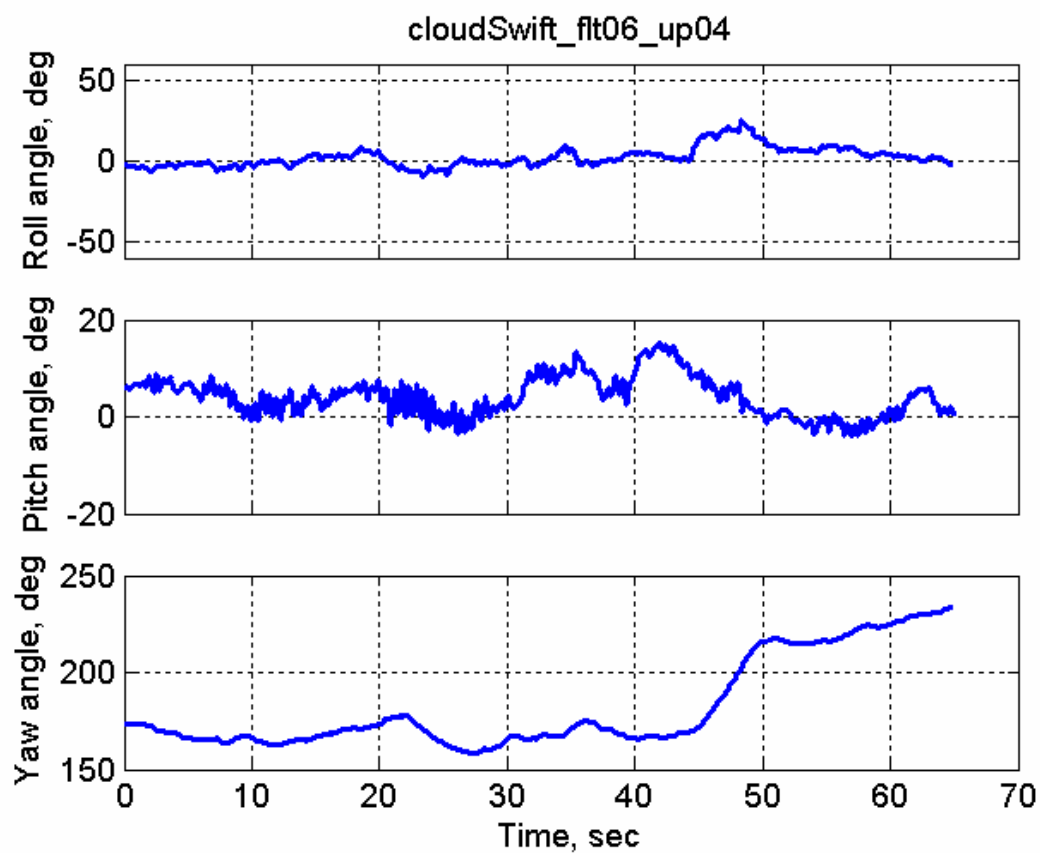
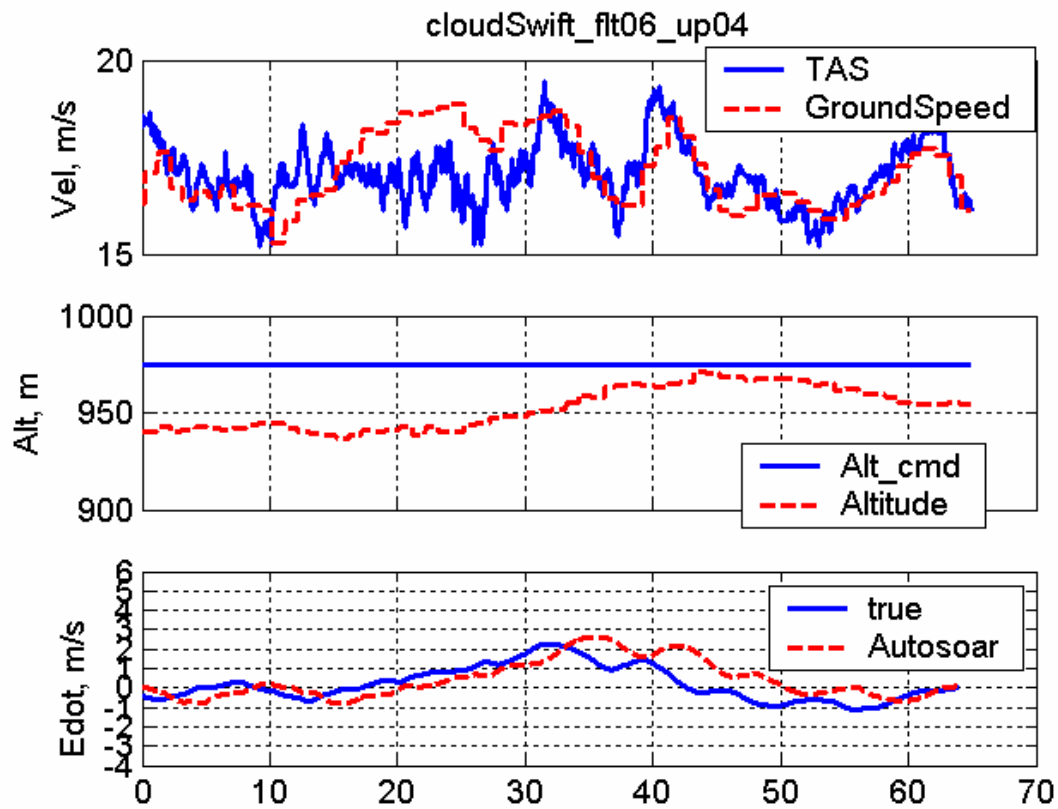


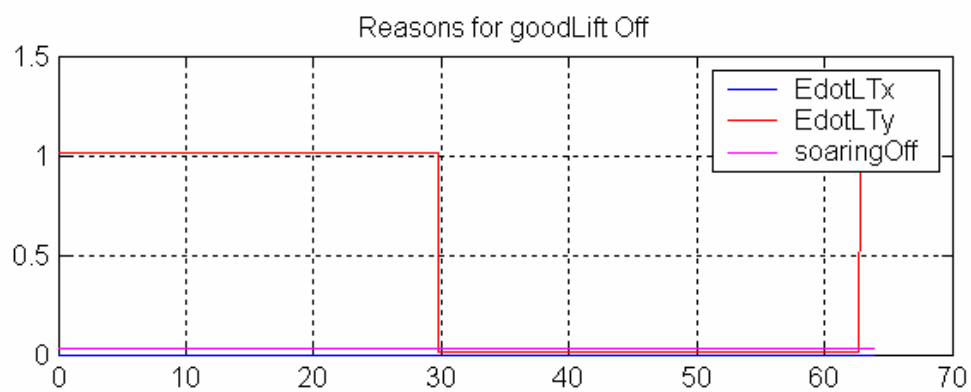
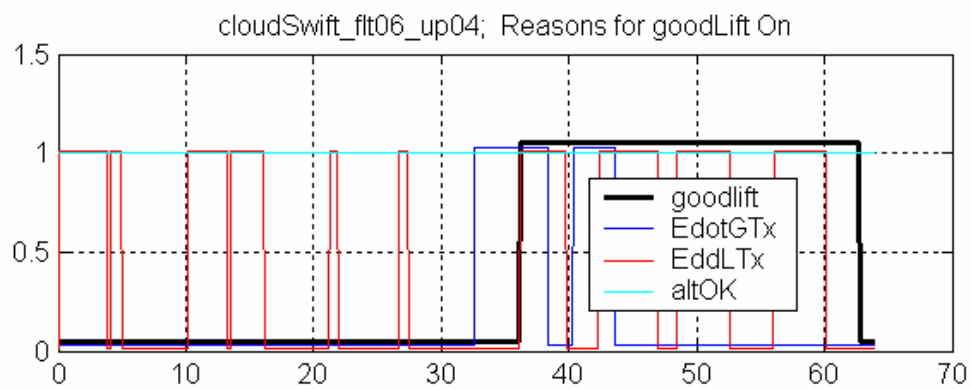
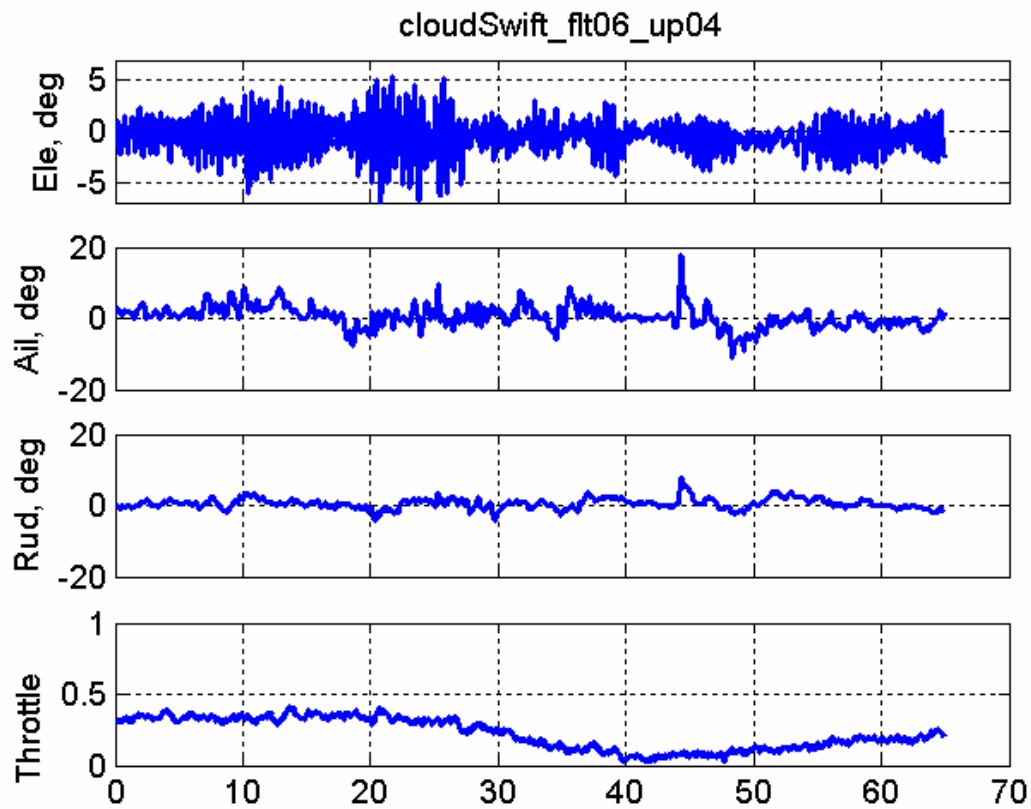


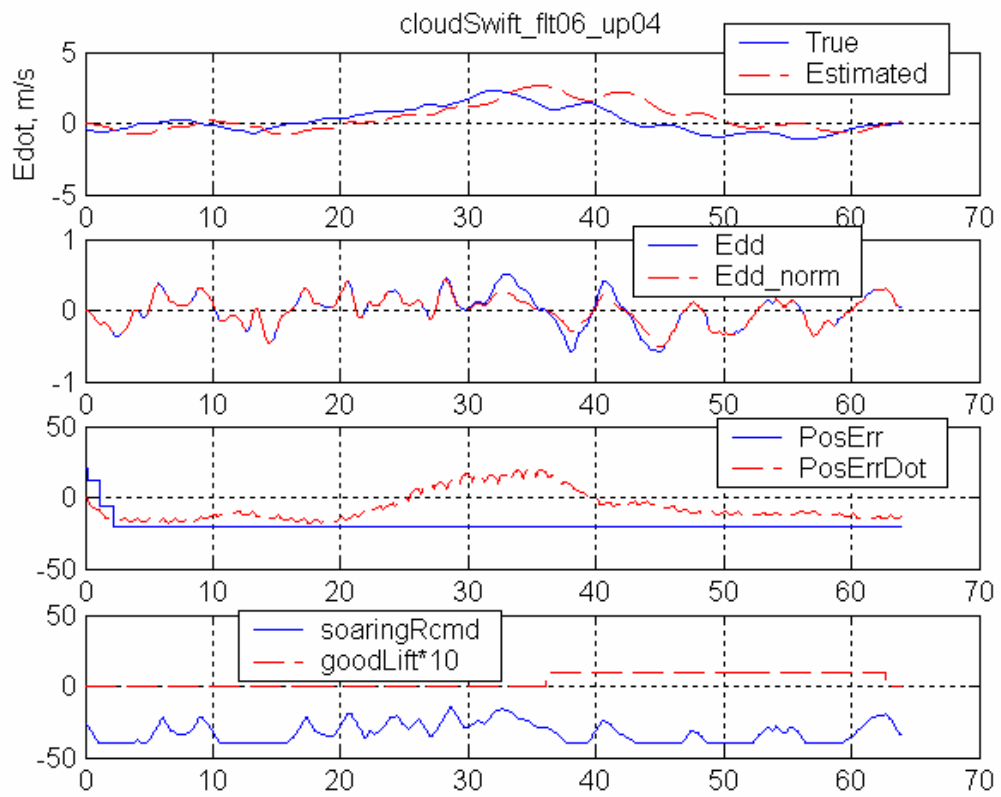


Flight 6, updraft 4



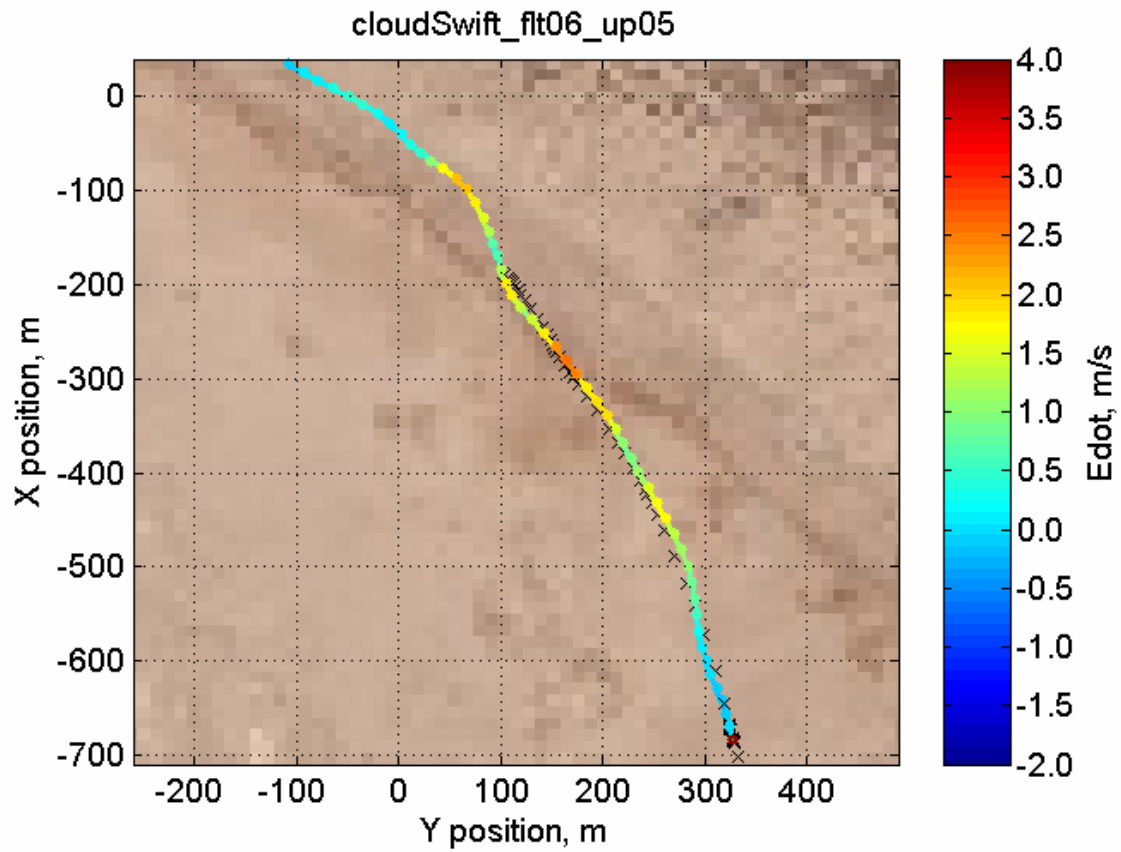


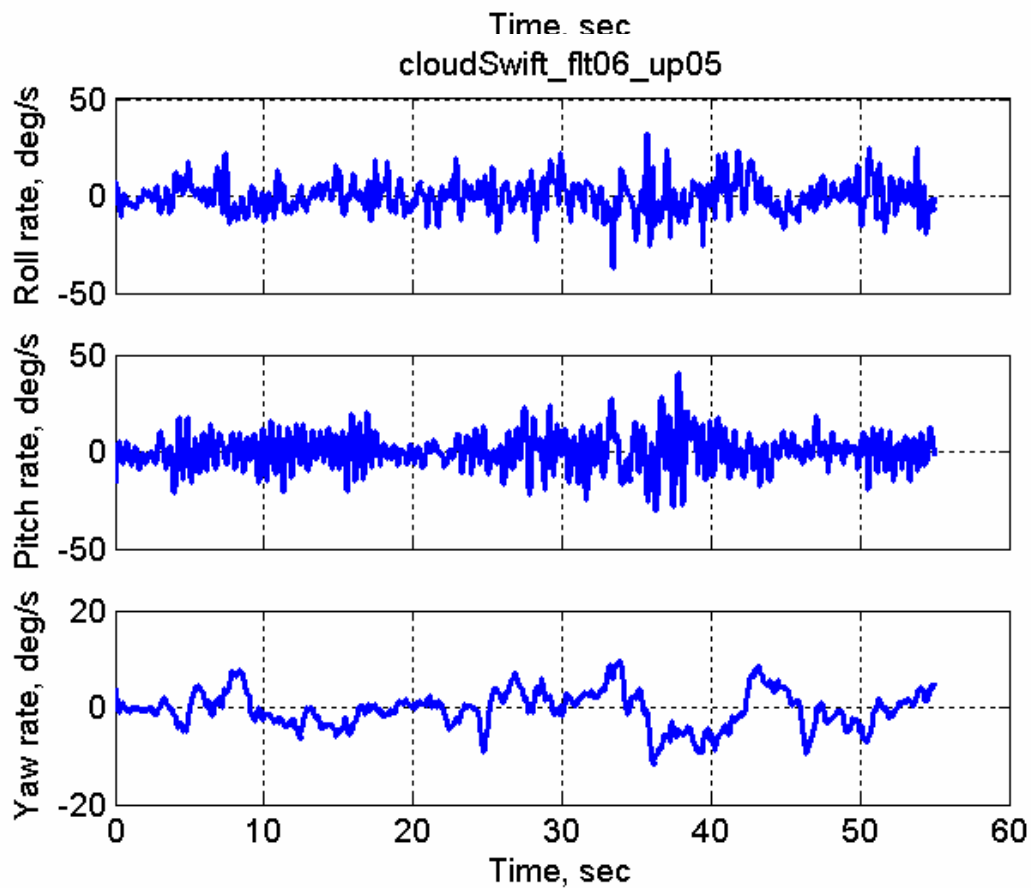
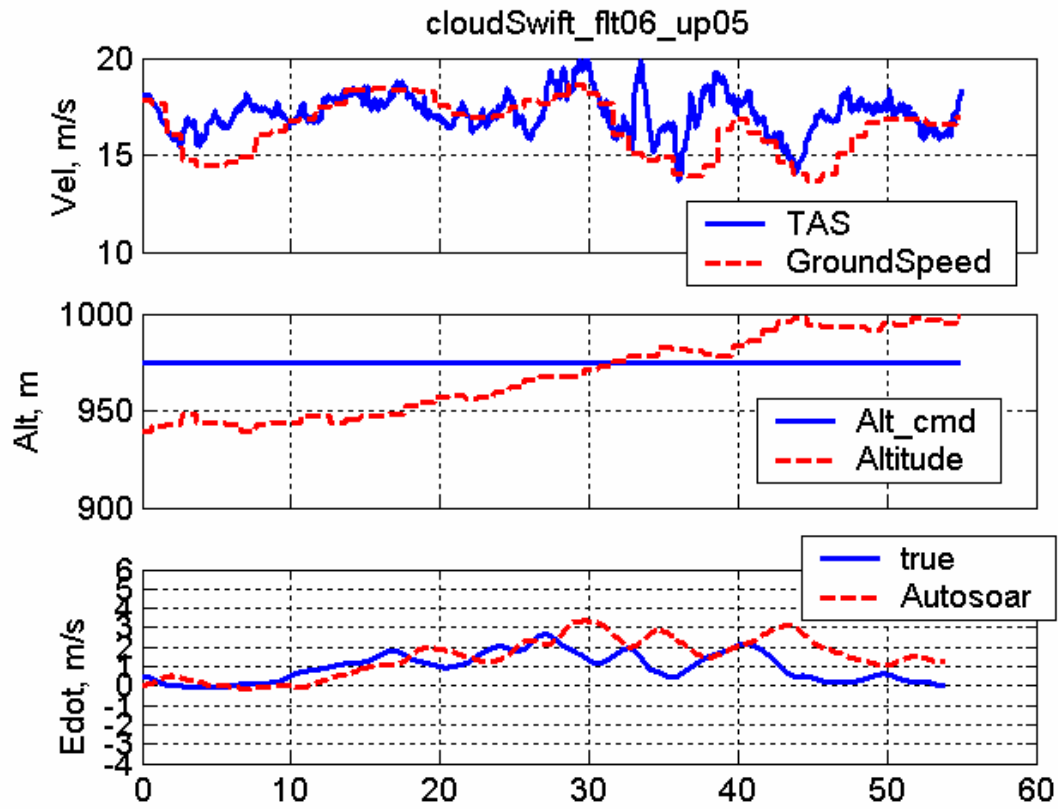


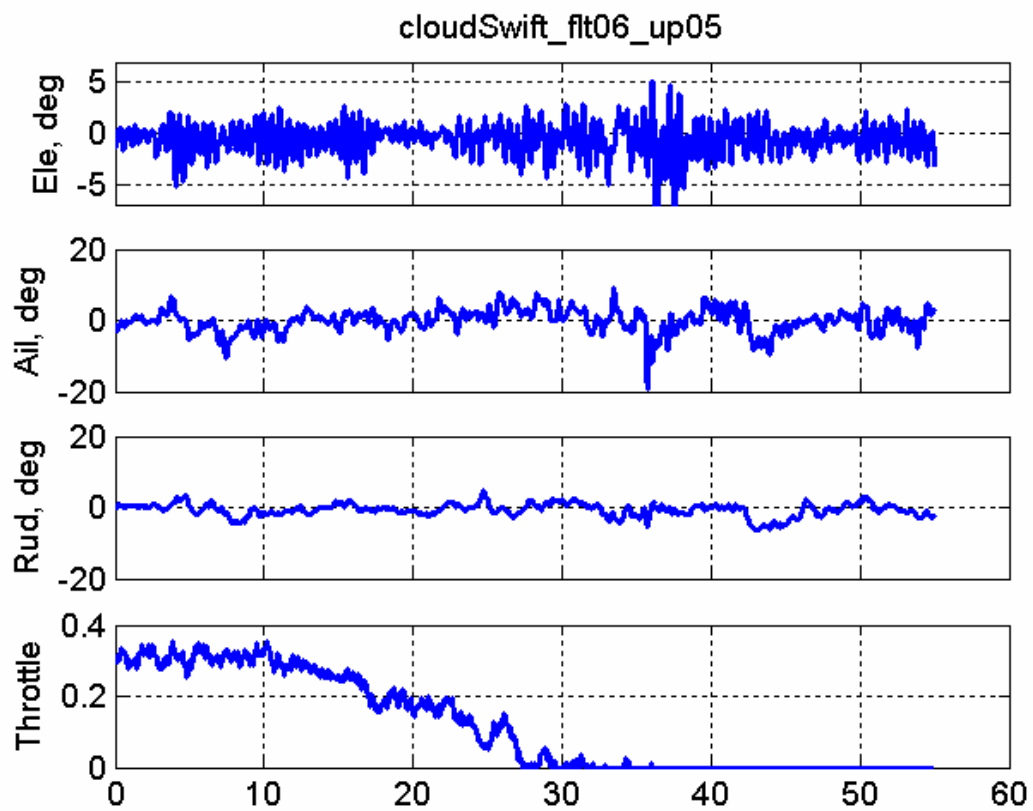
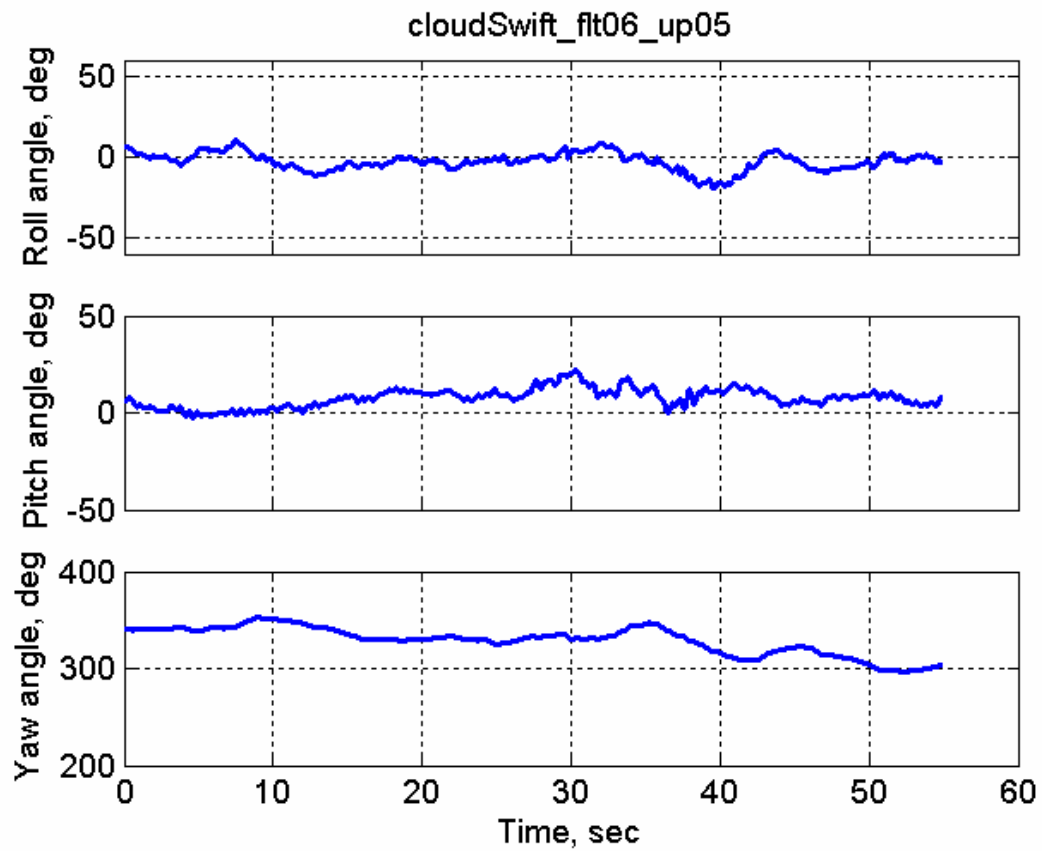


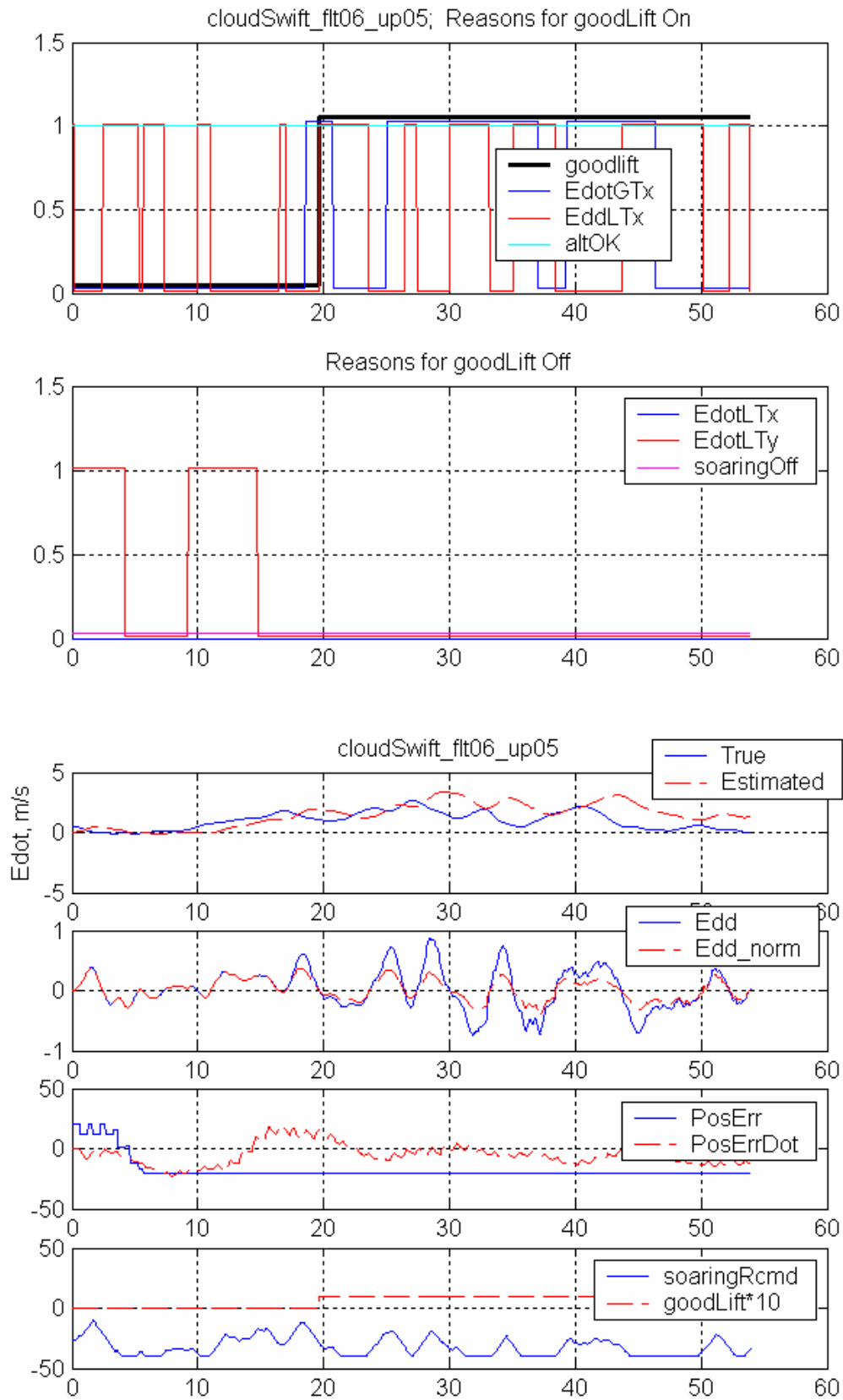
Flight 6, updraft 5

Note the aileron deflection used while traversing the thermal.

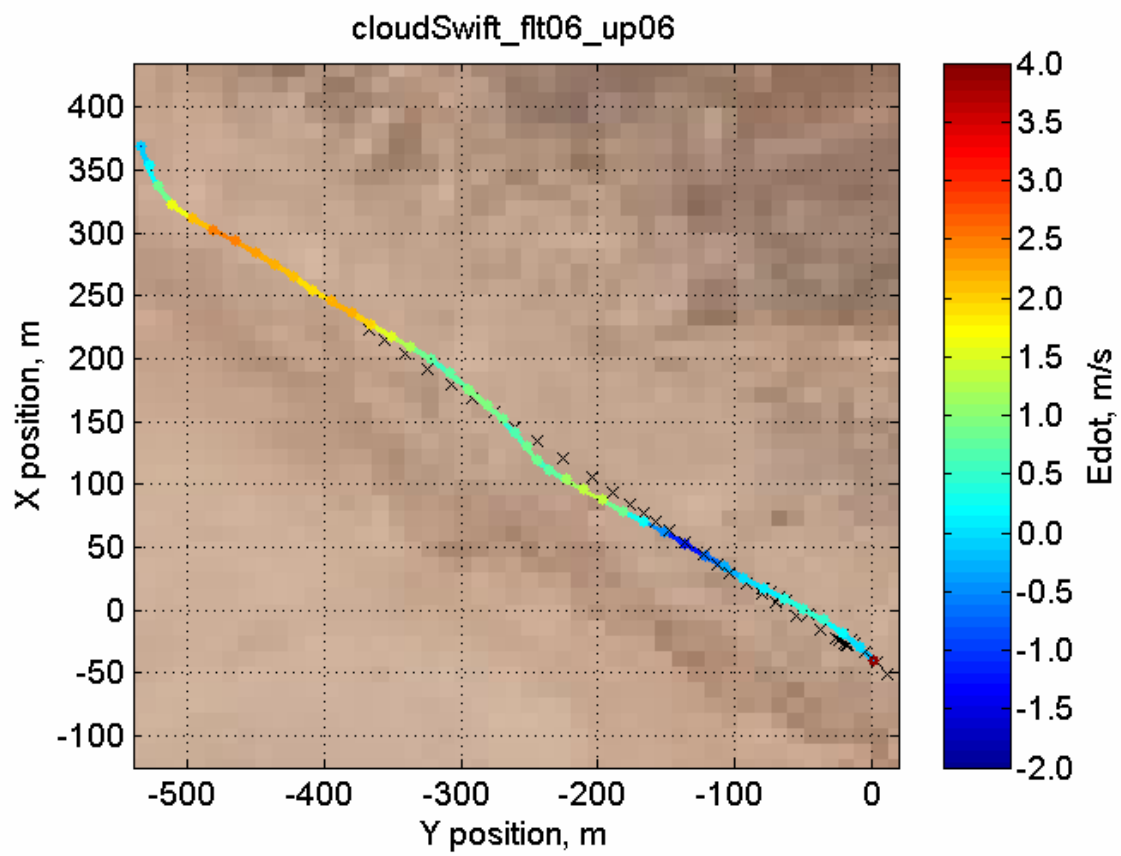


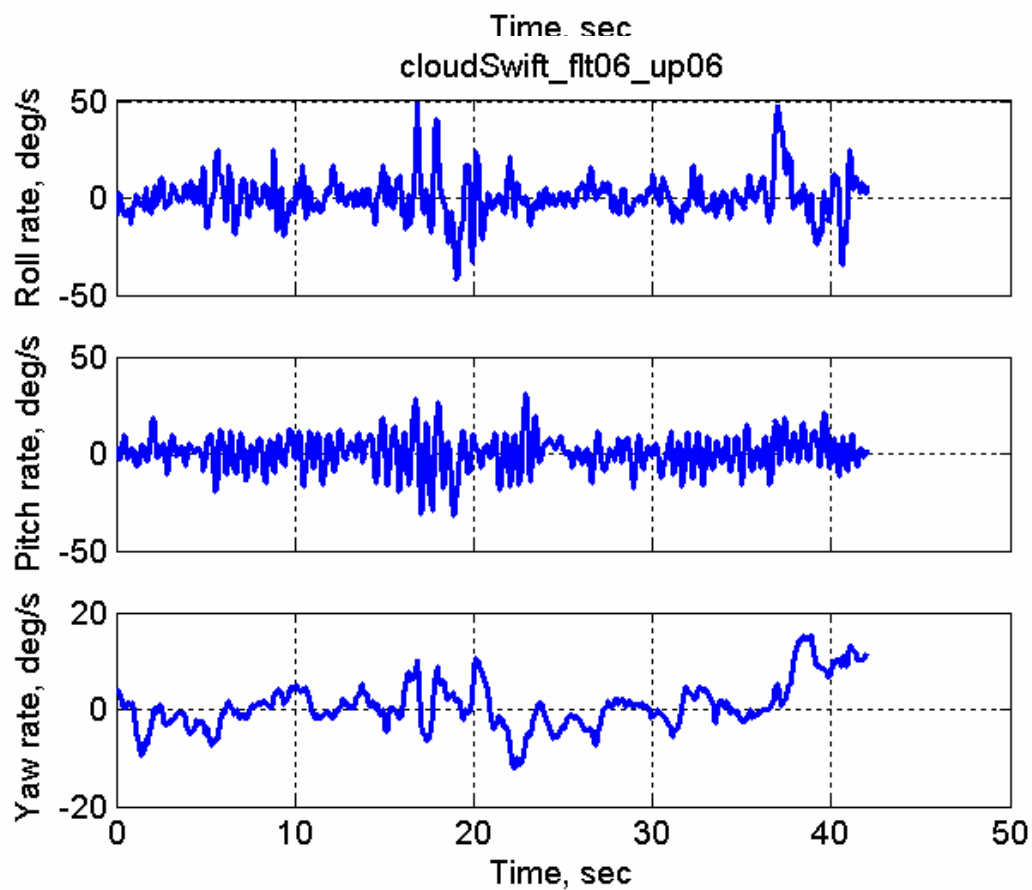
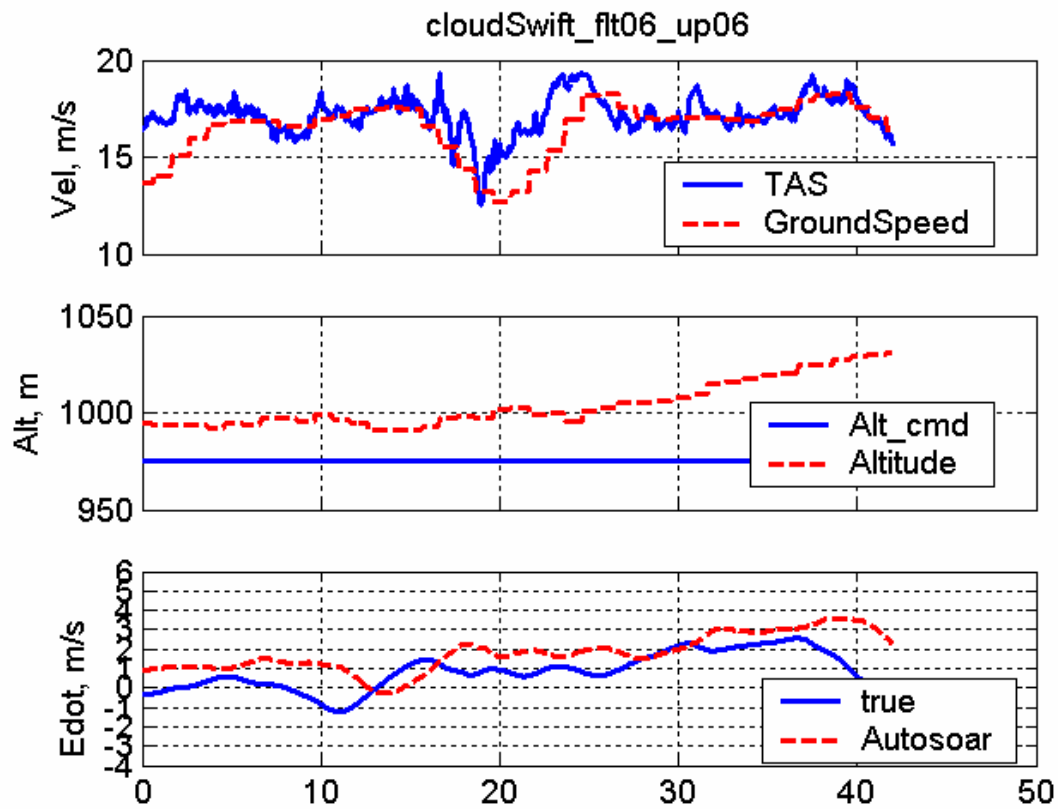


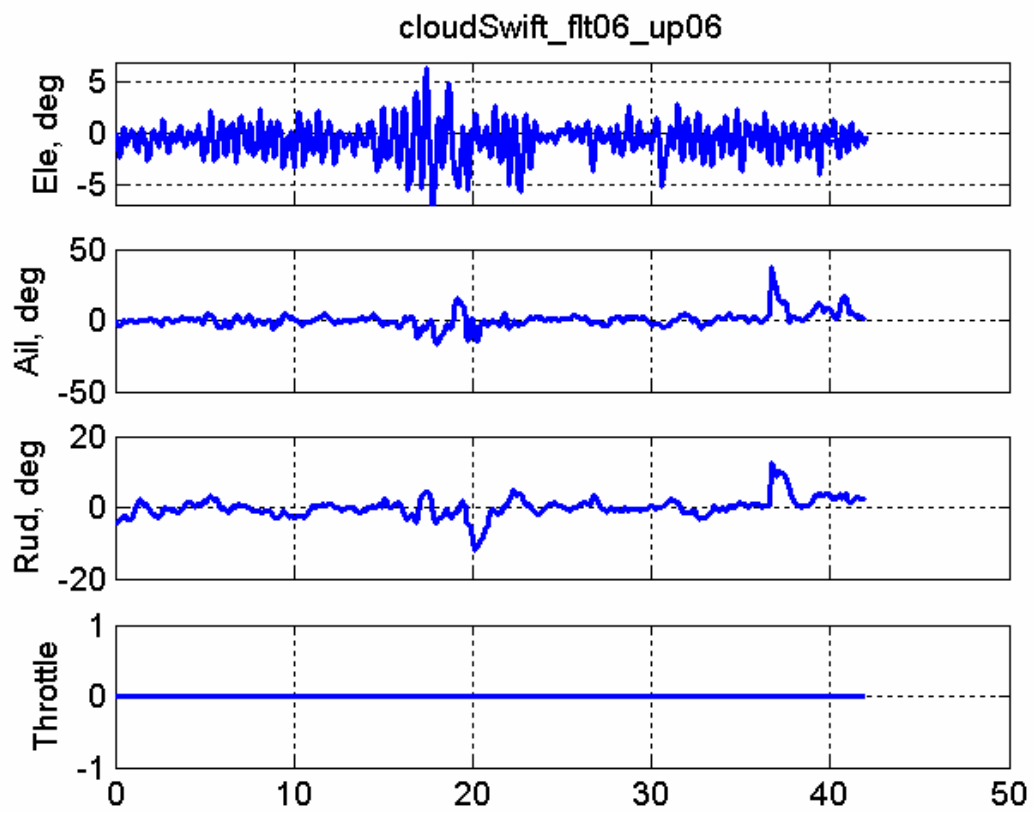
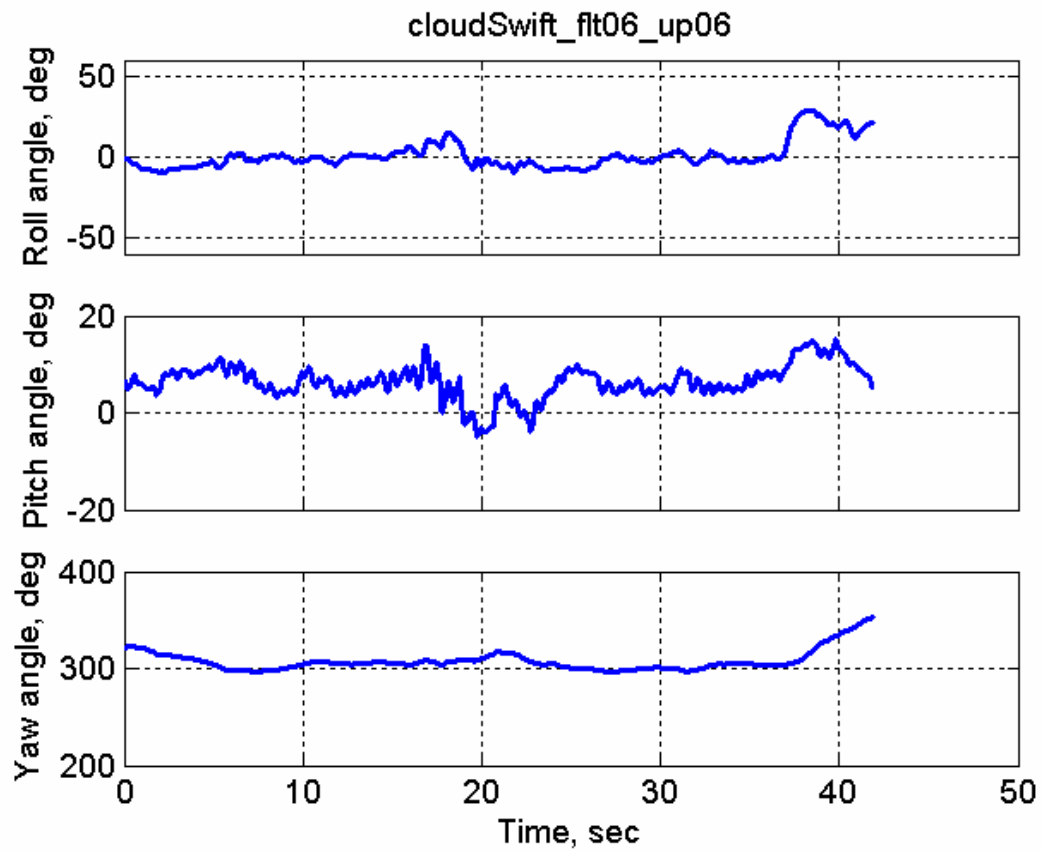


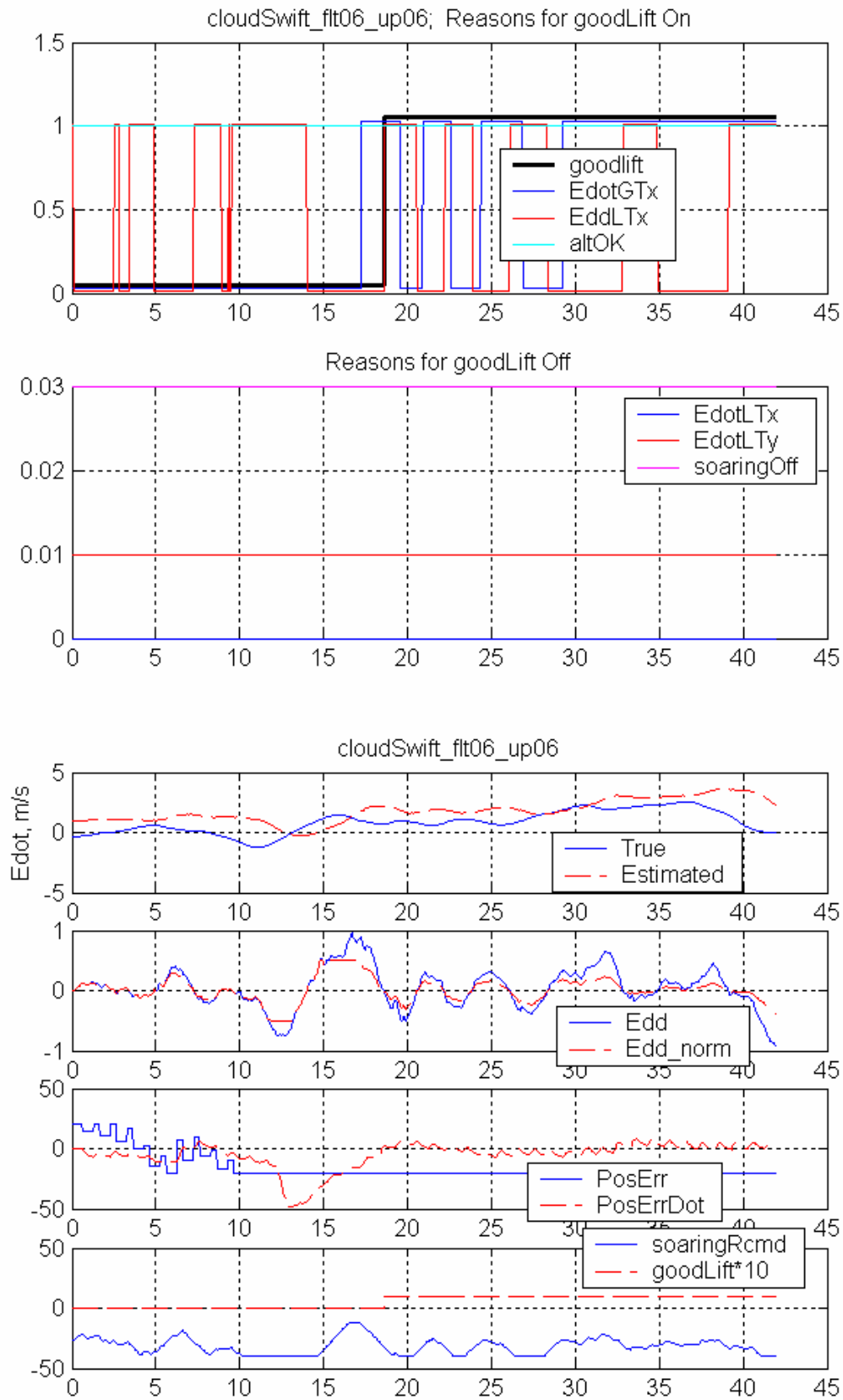


Flight 6, updraft 6



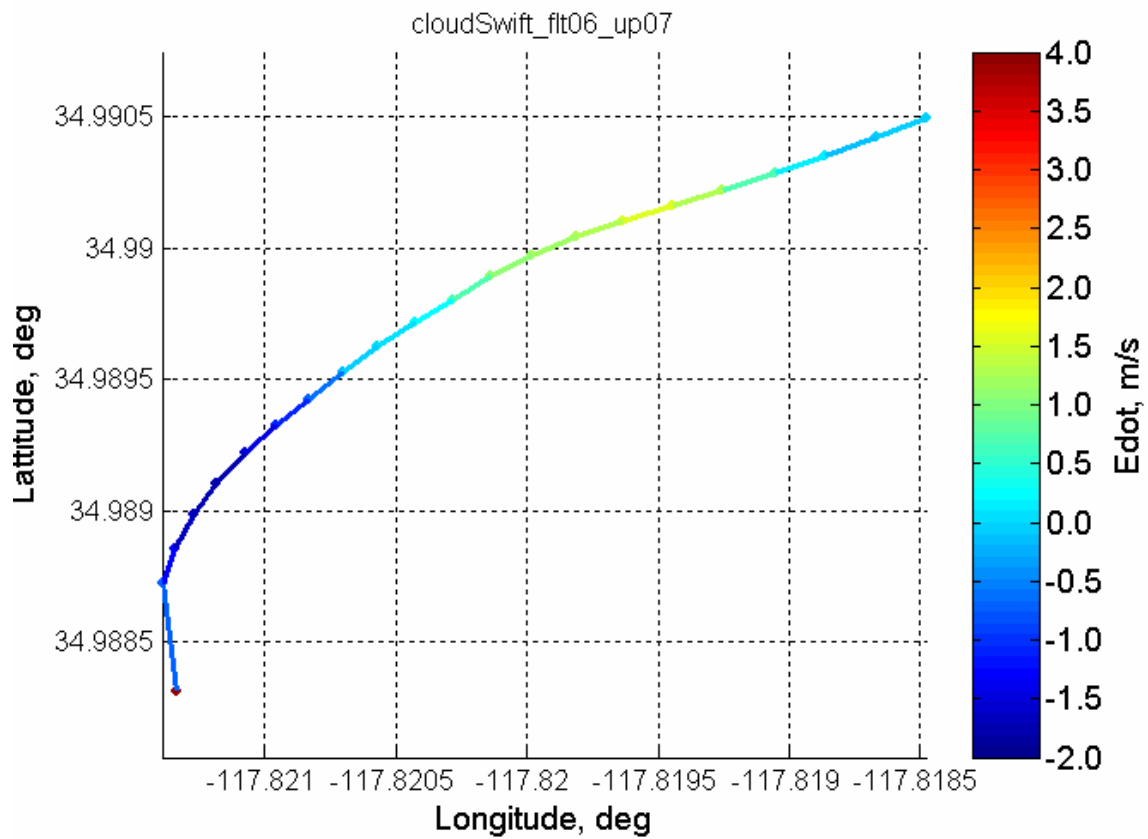


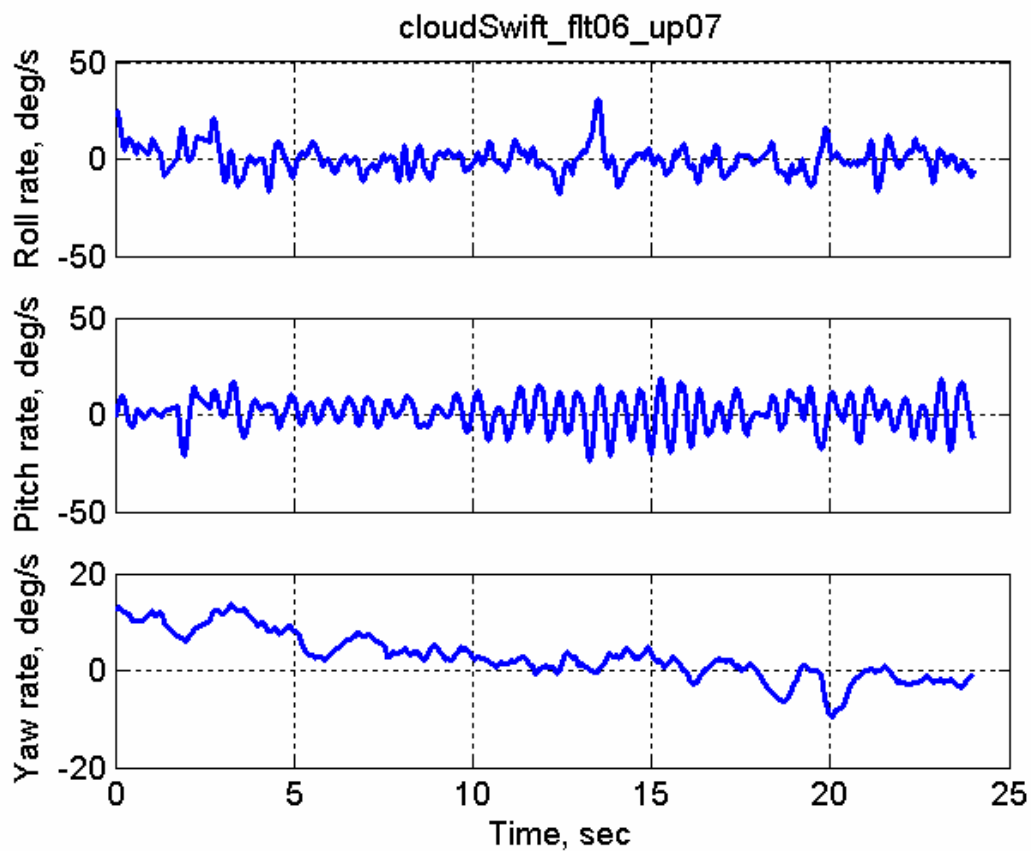
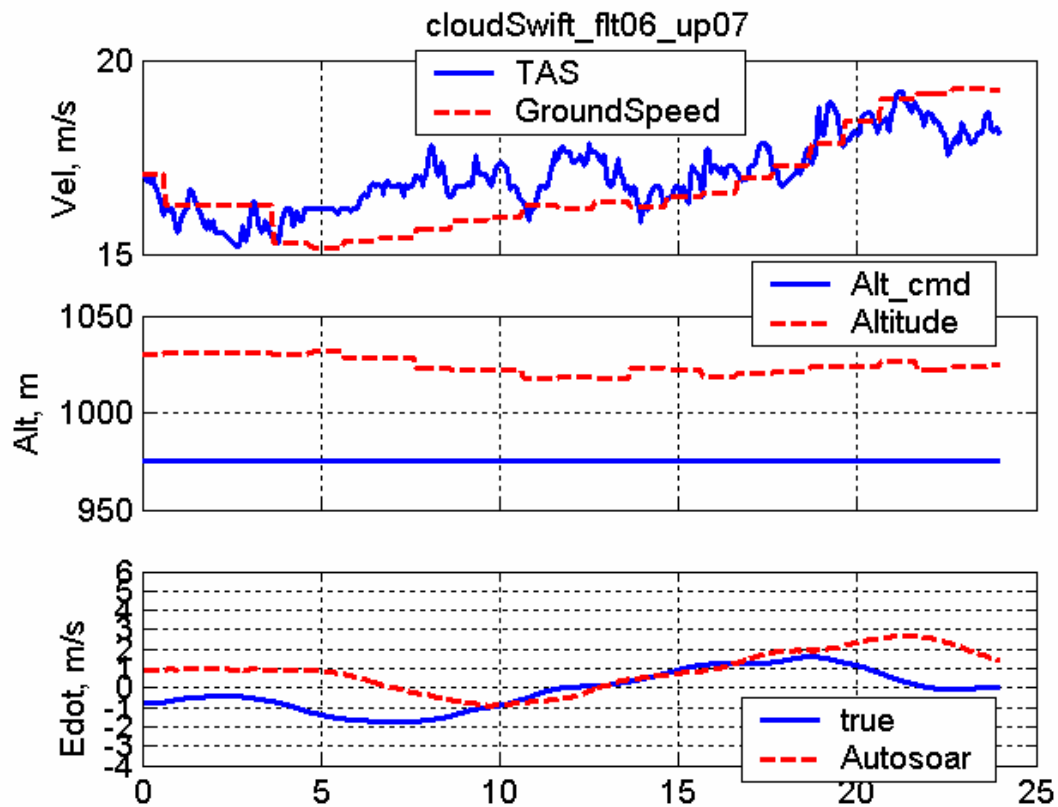


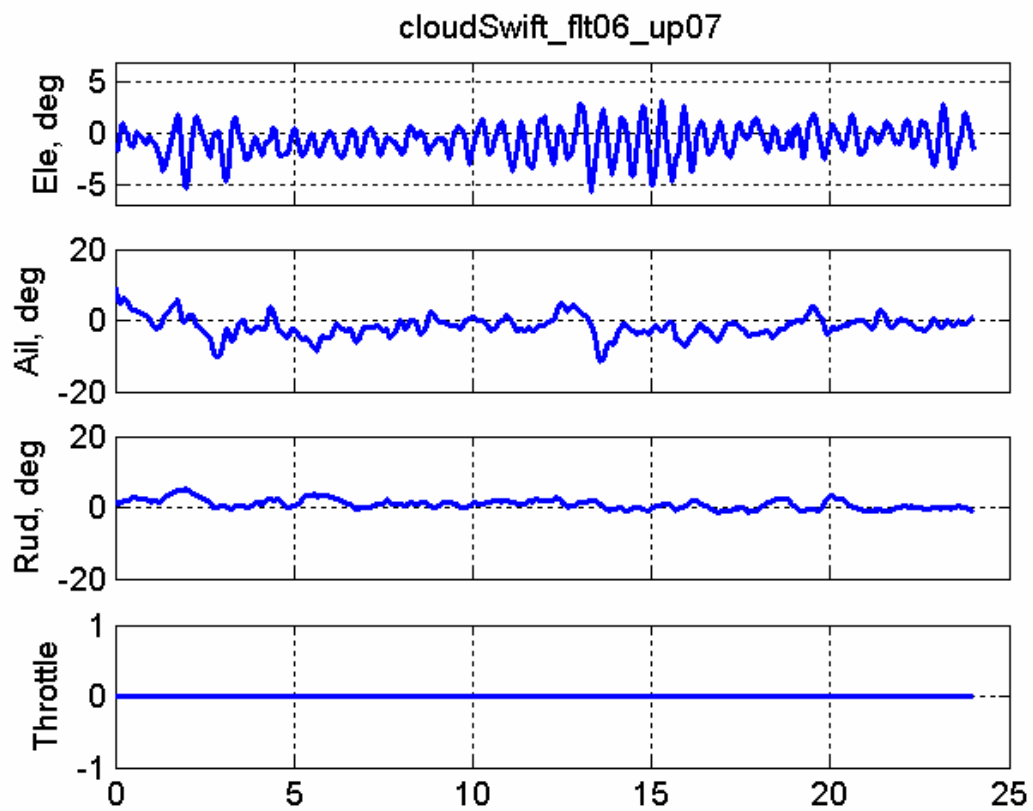
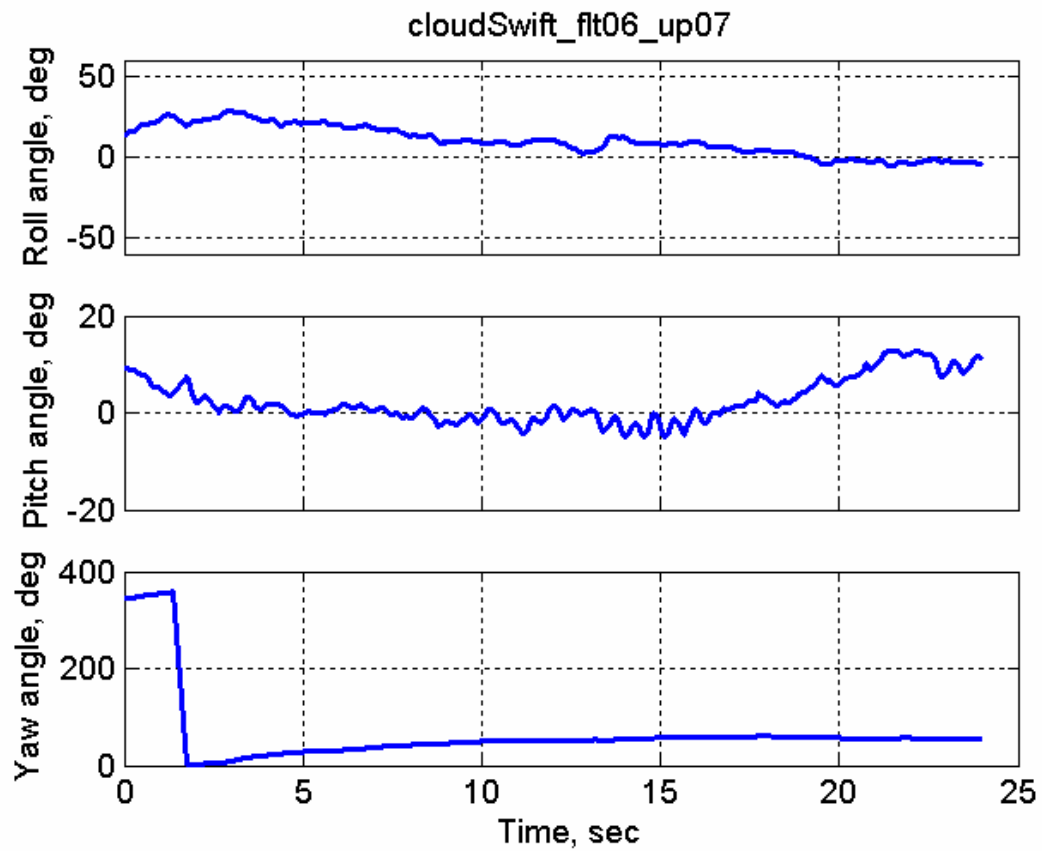


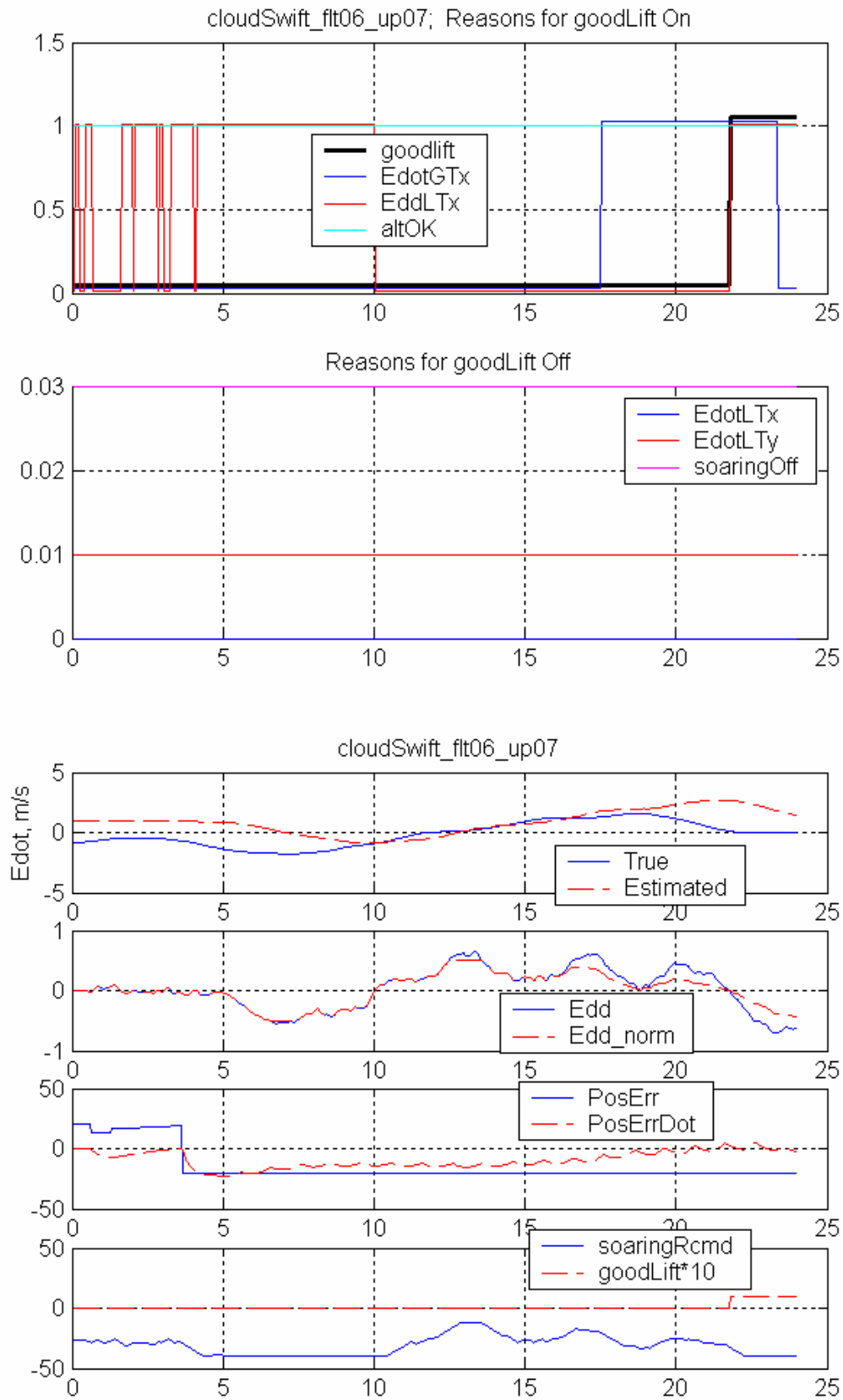
Flight 6, updraft 7

Note the left aileron held during climb through thermal.

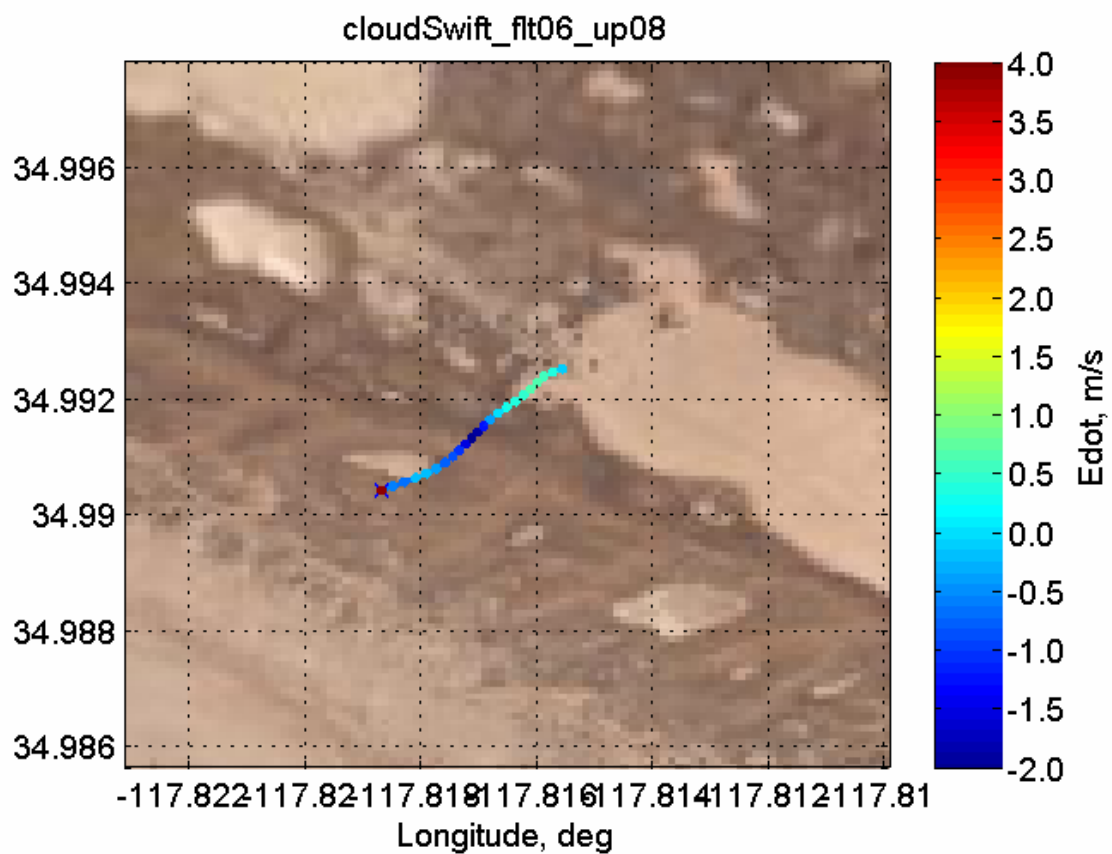


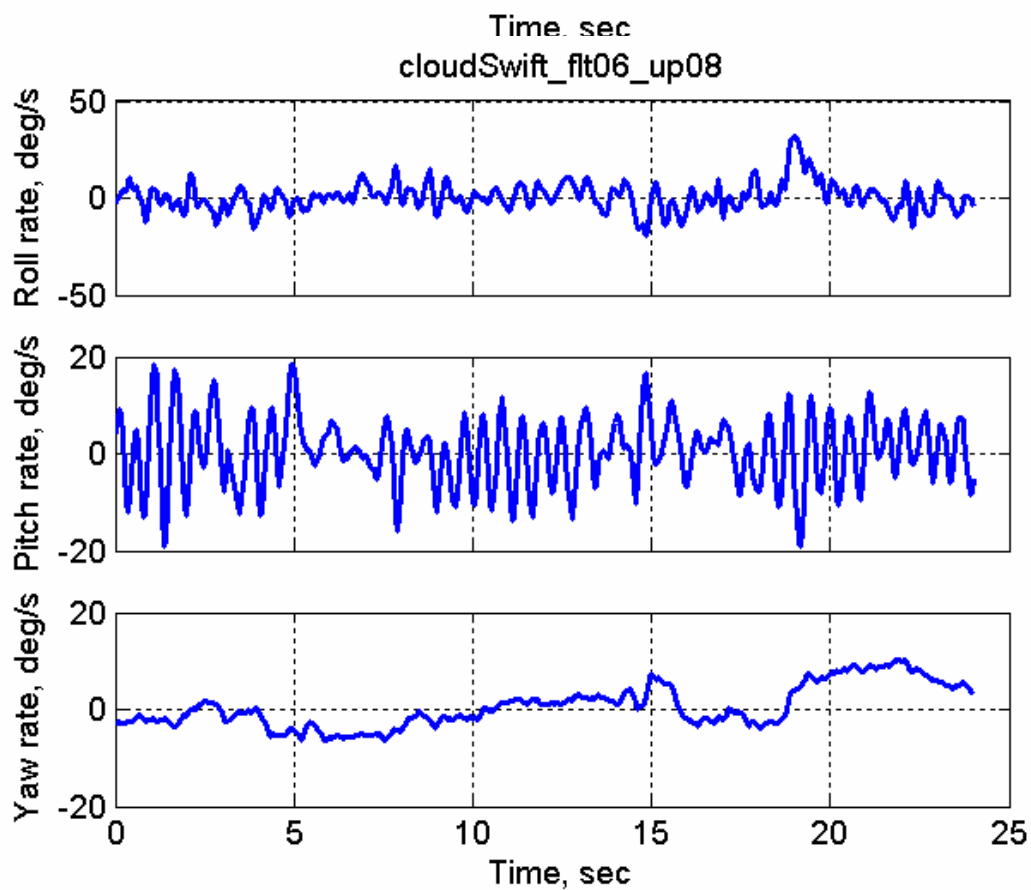
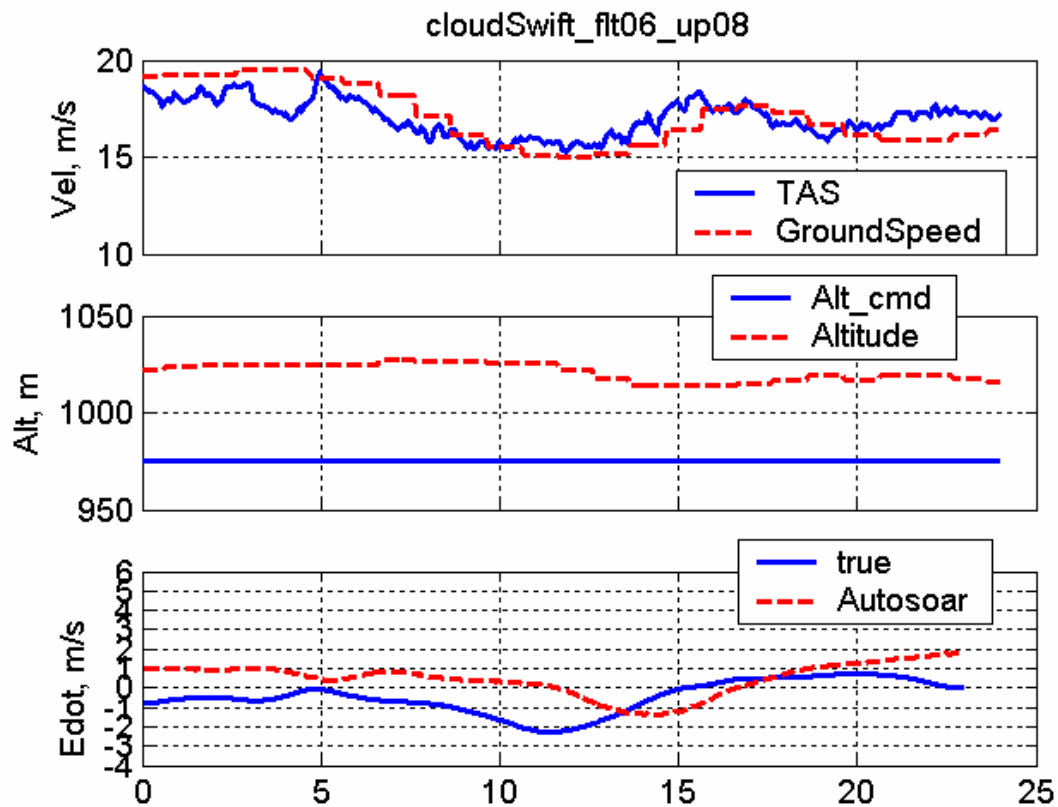


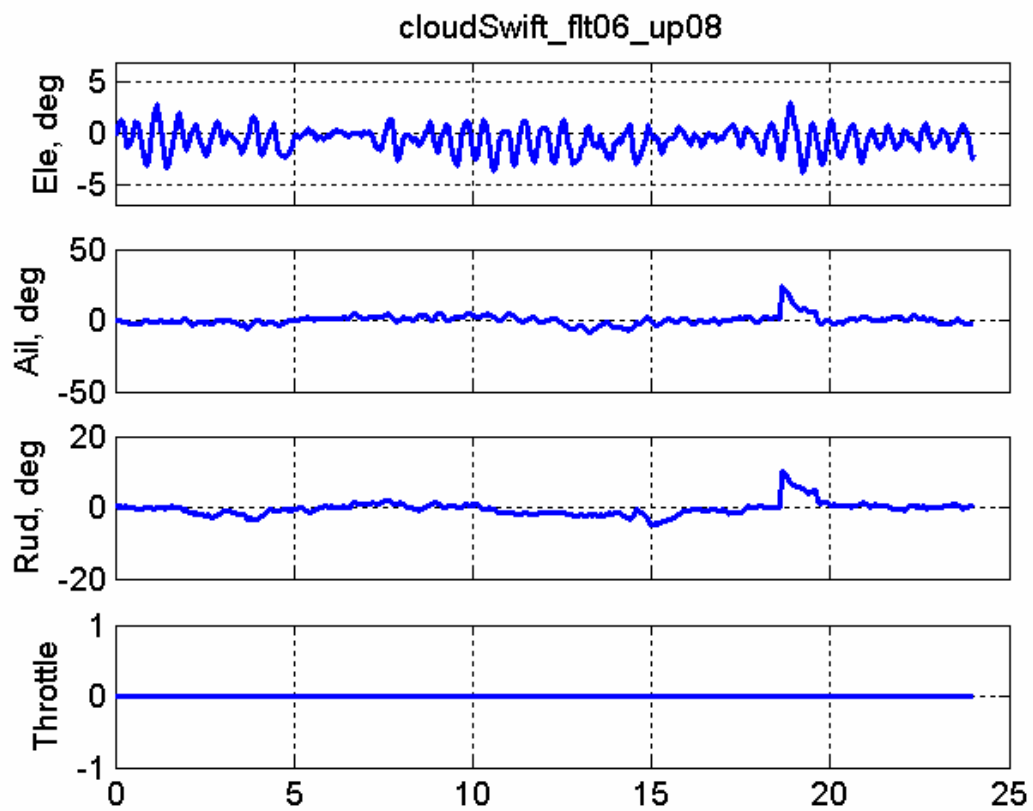
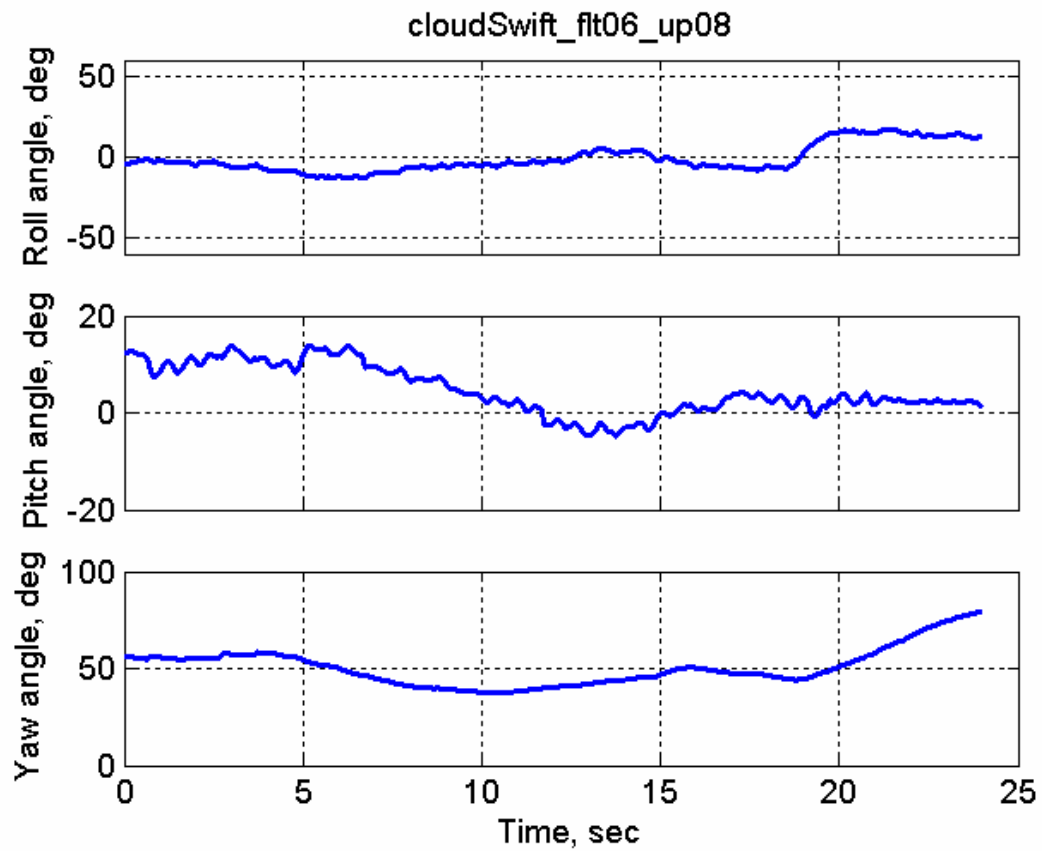


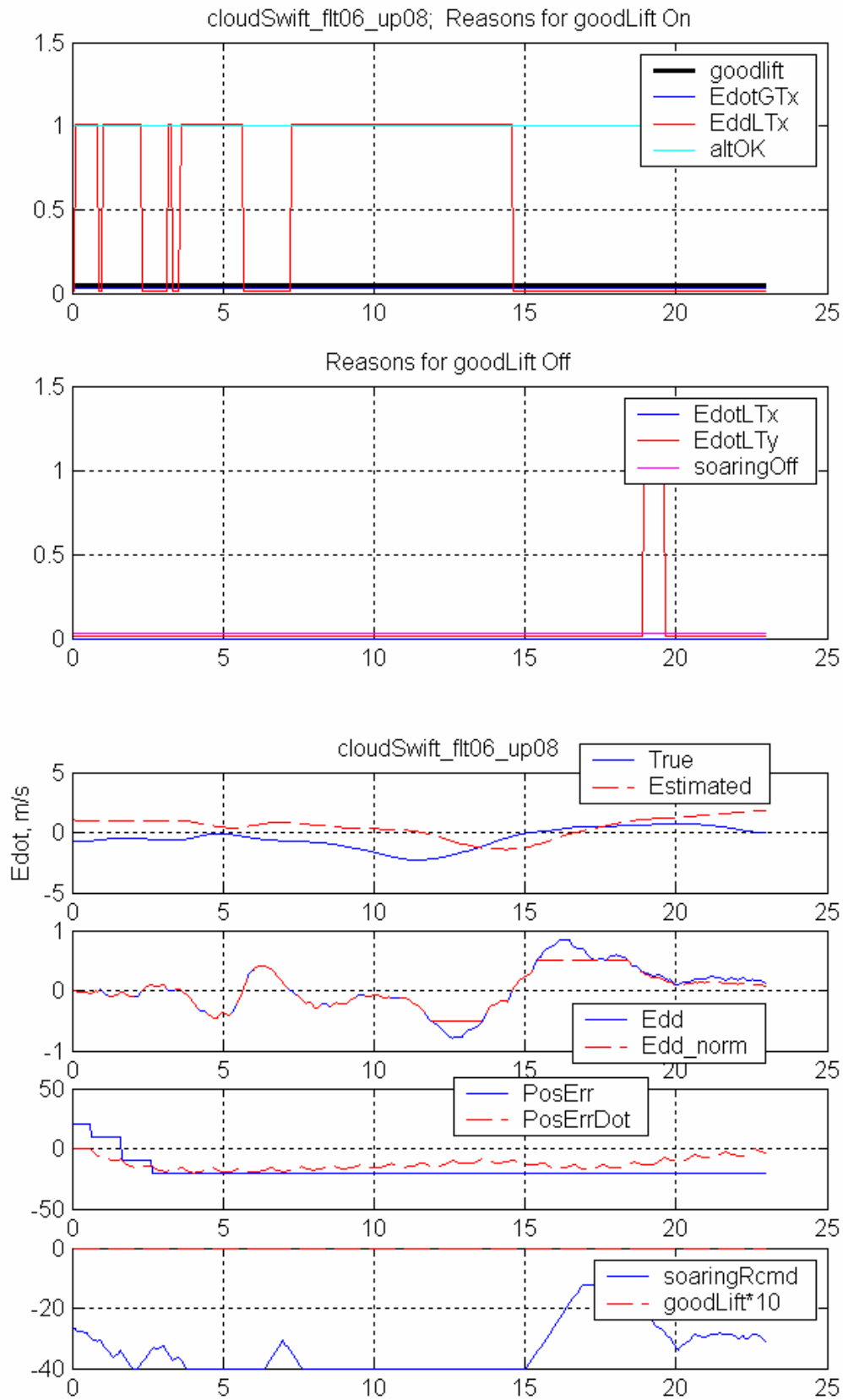


Flight 6, updraft 8

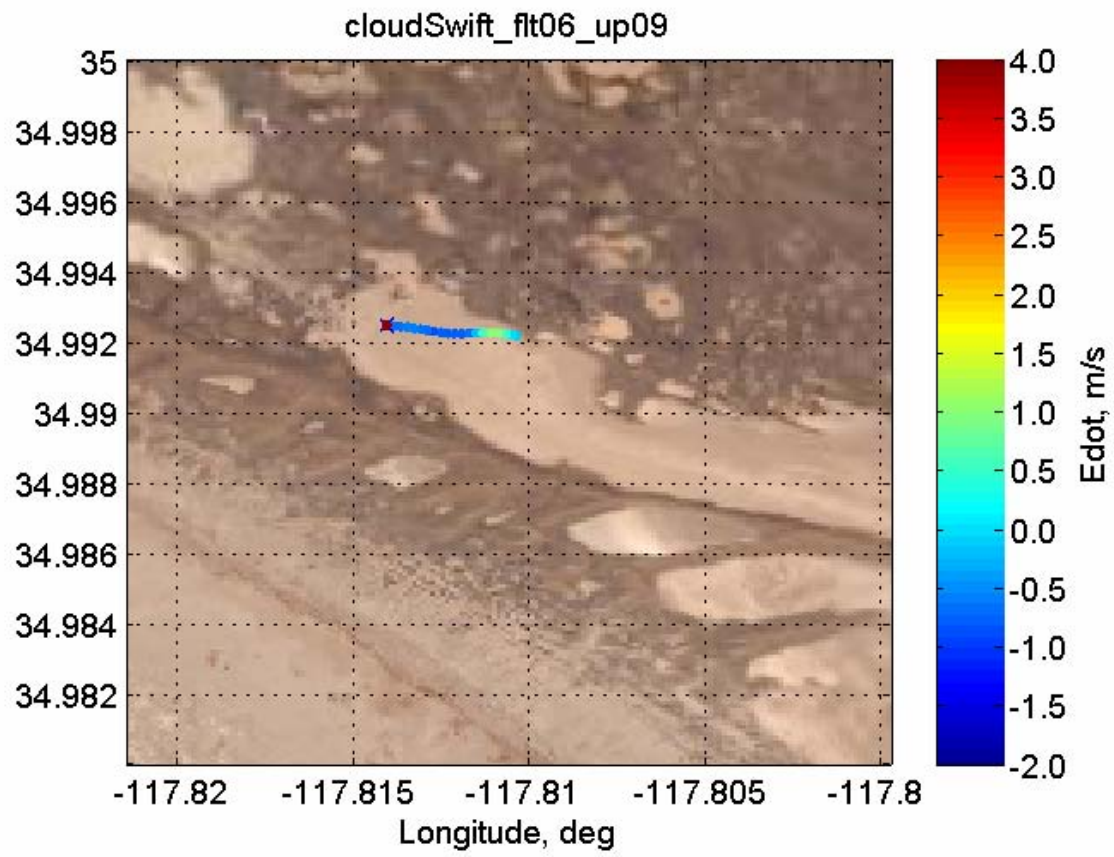


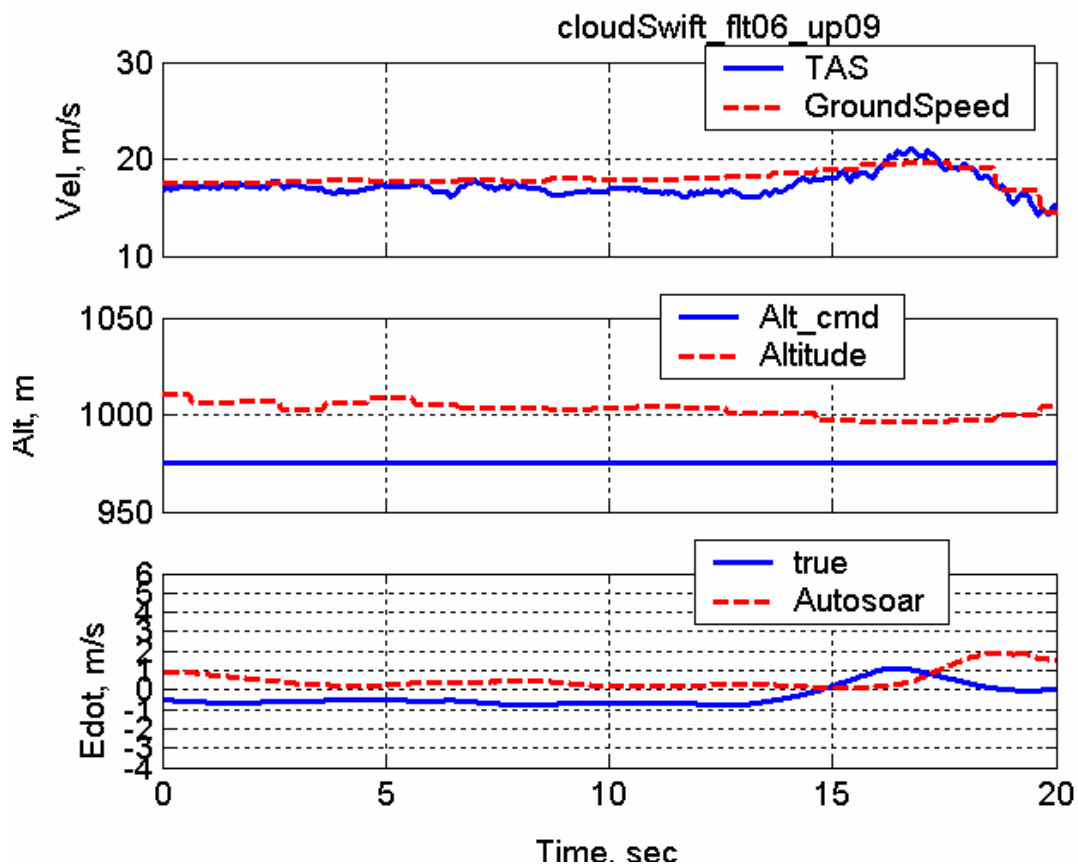
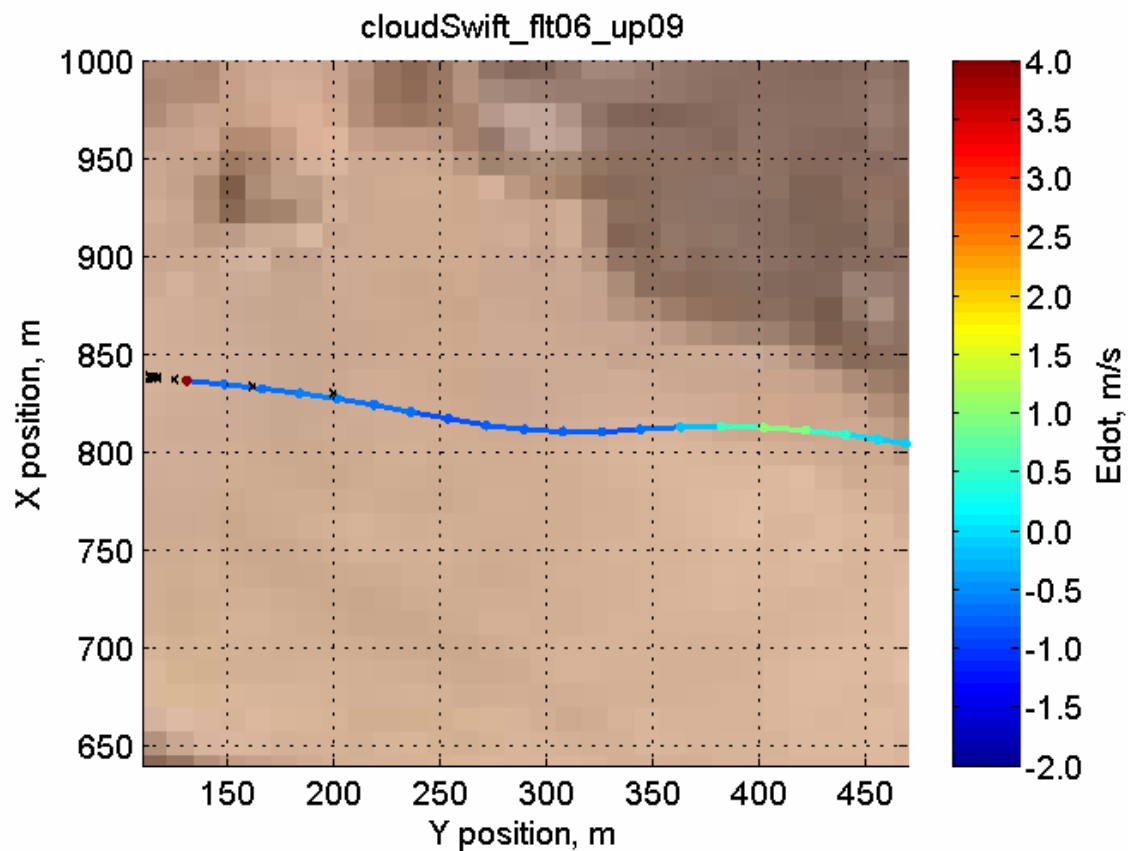


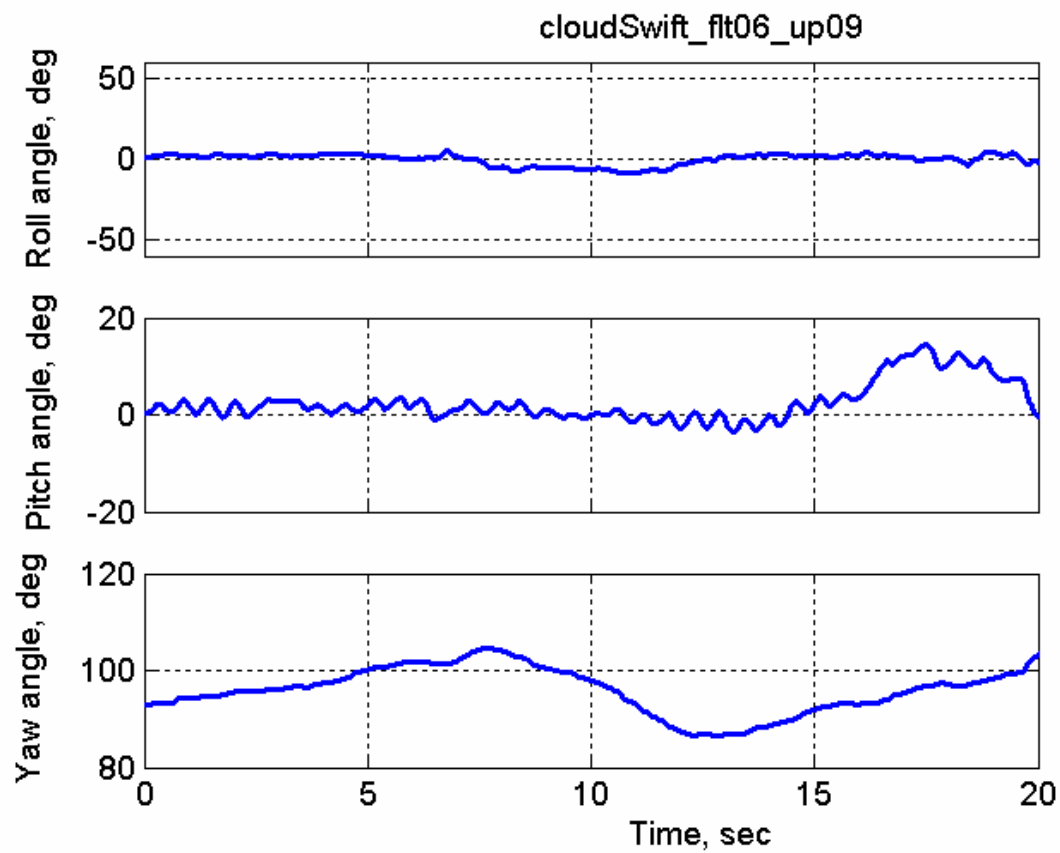
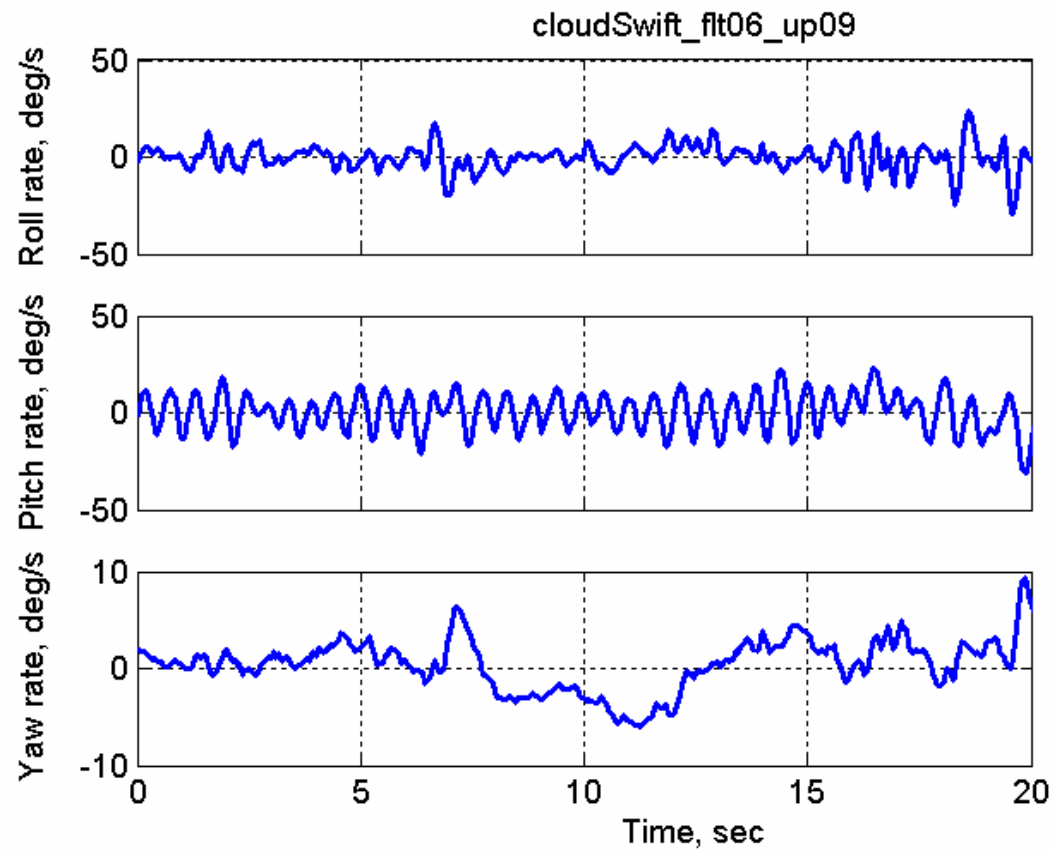


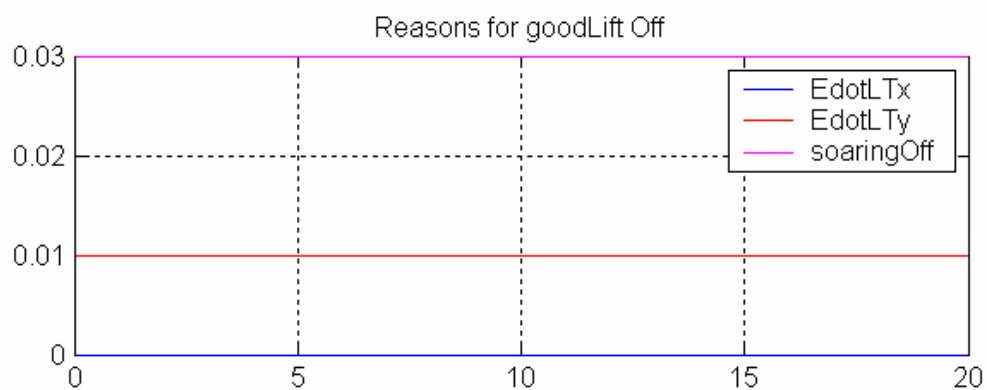
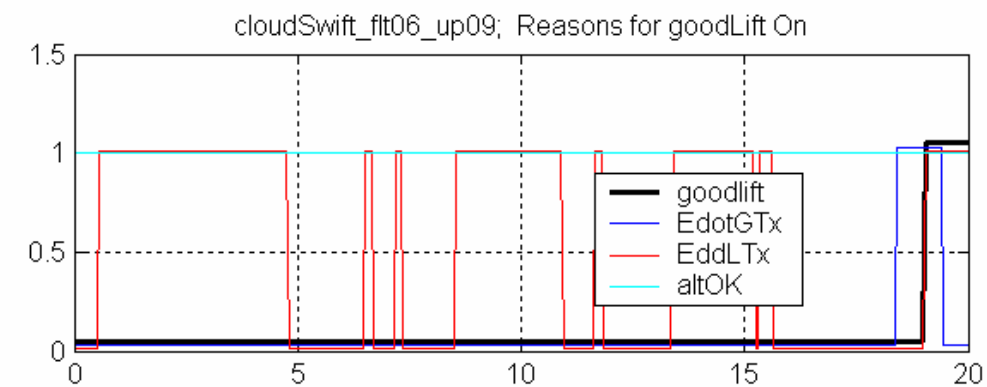
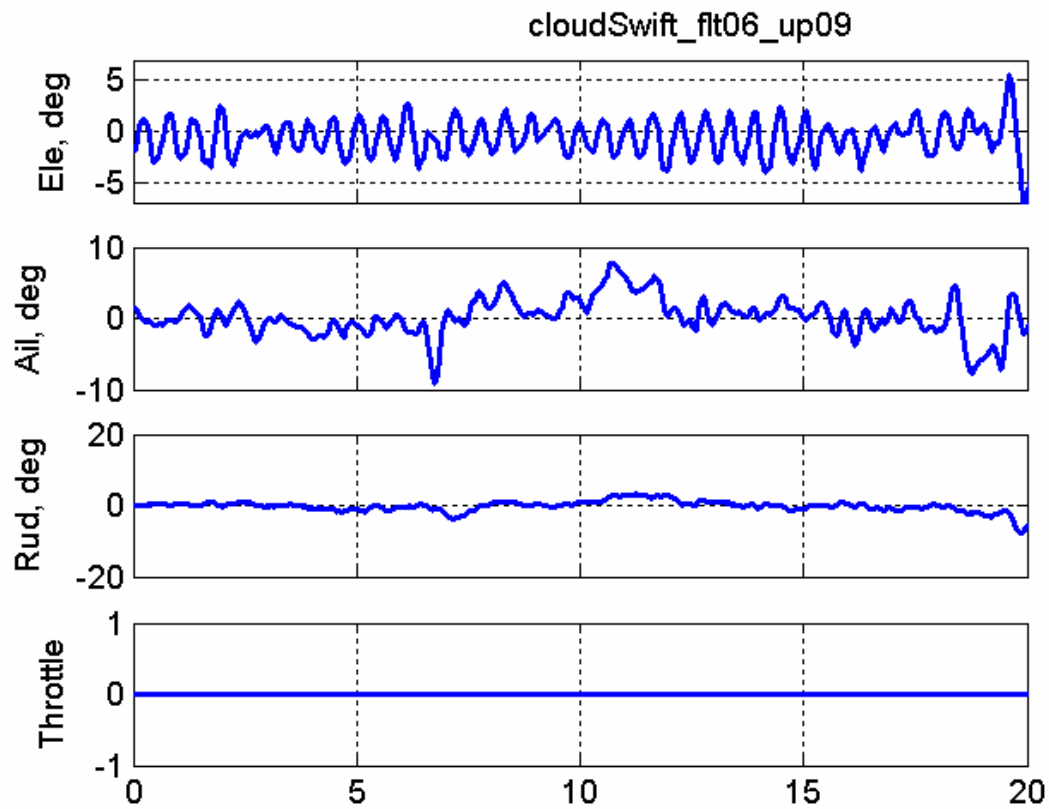


Flight 6, updraft 9

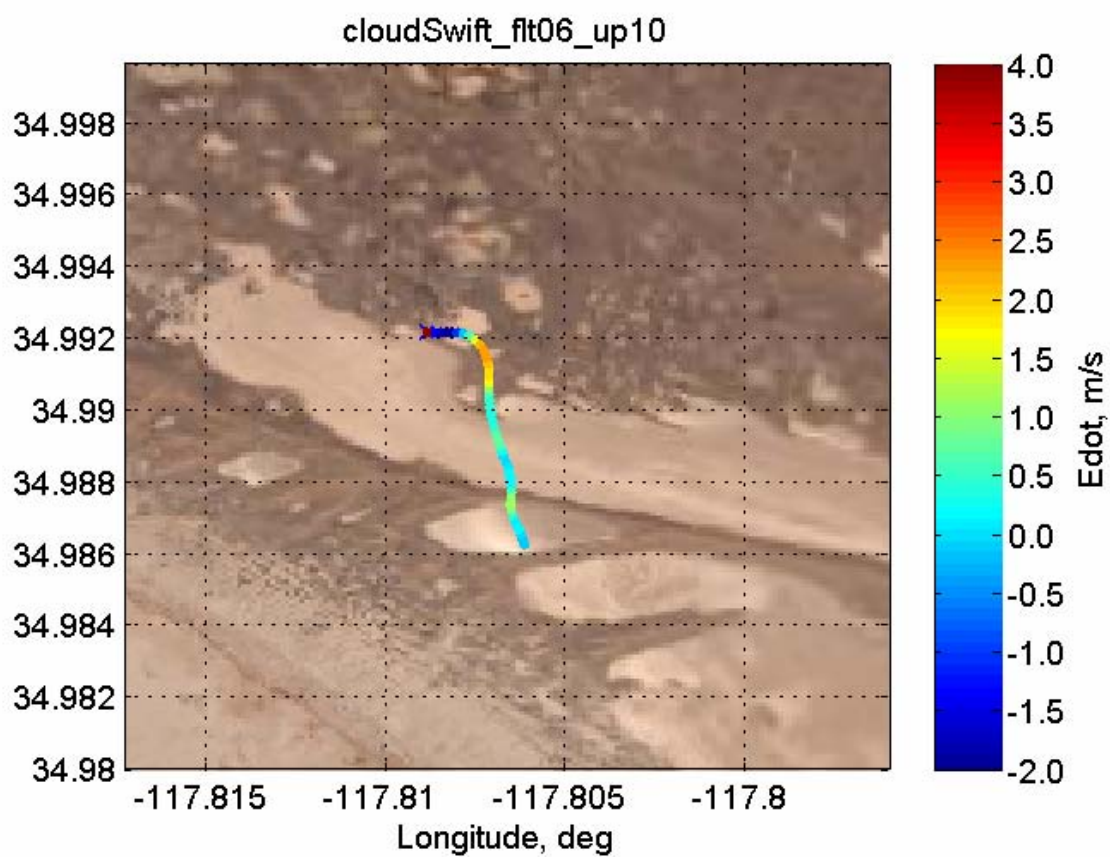


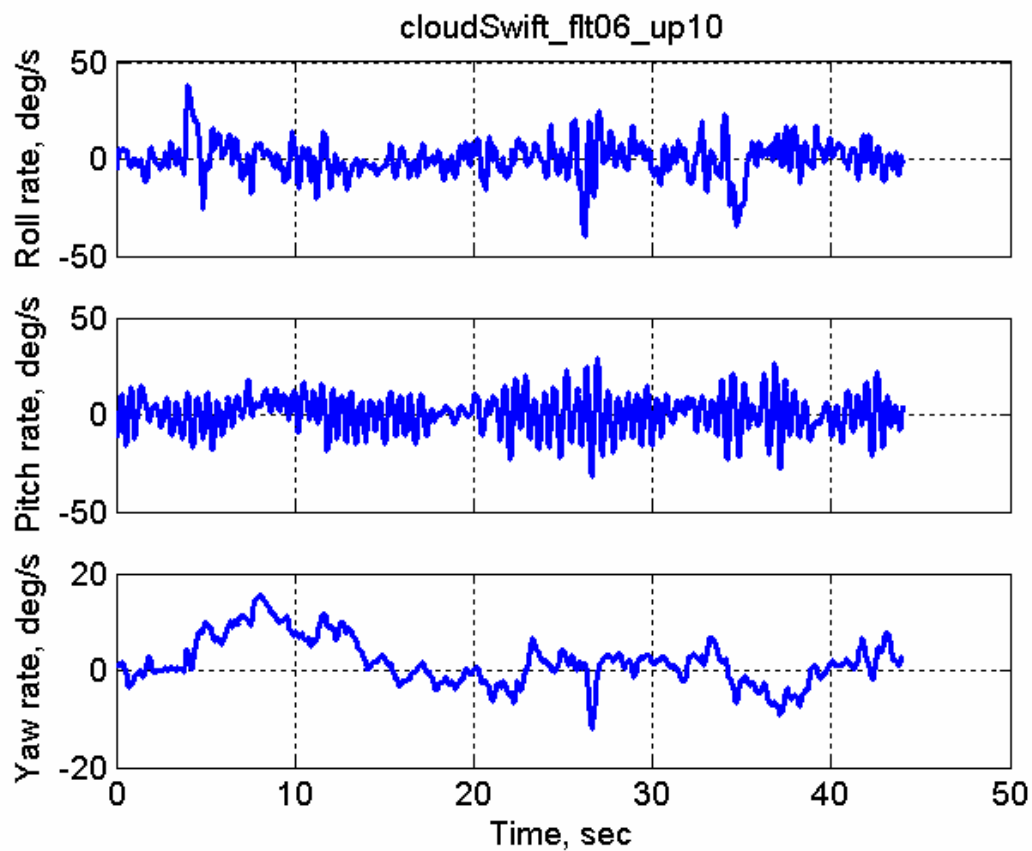
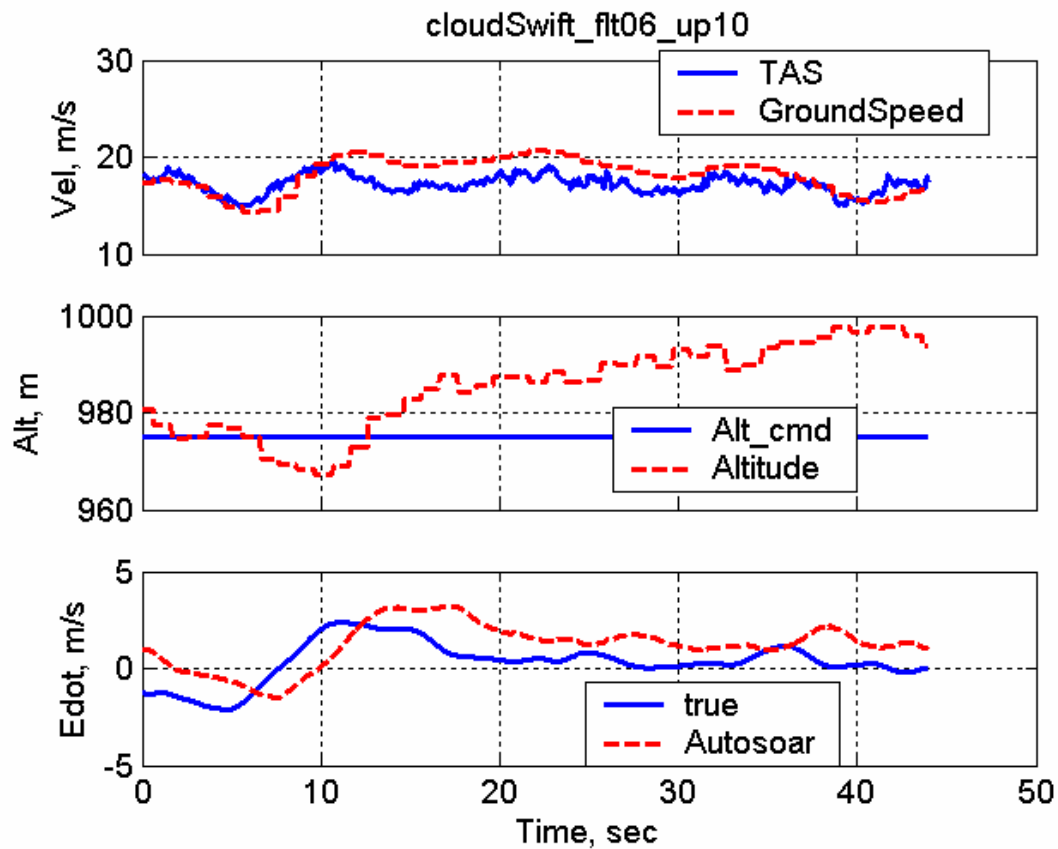


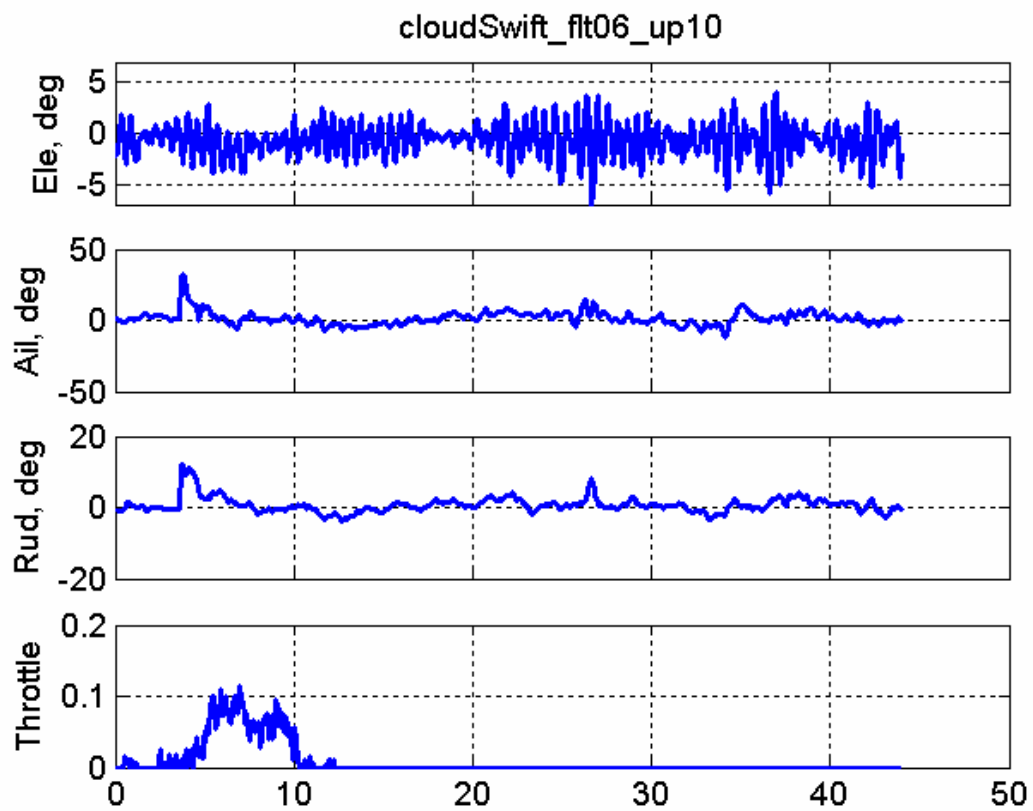
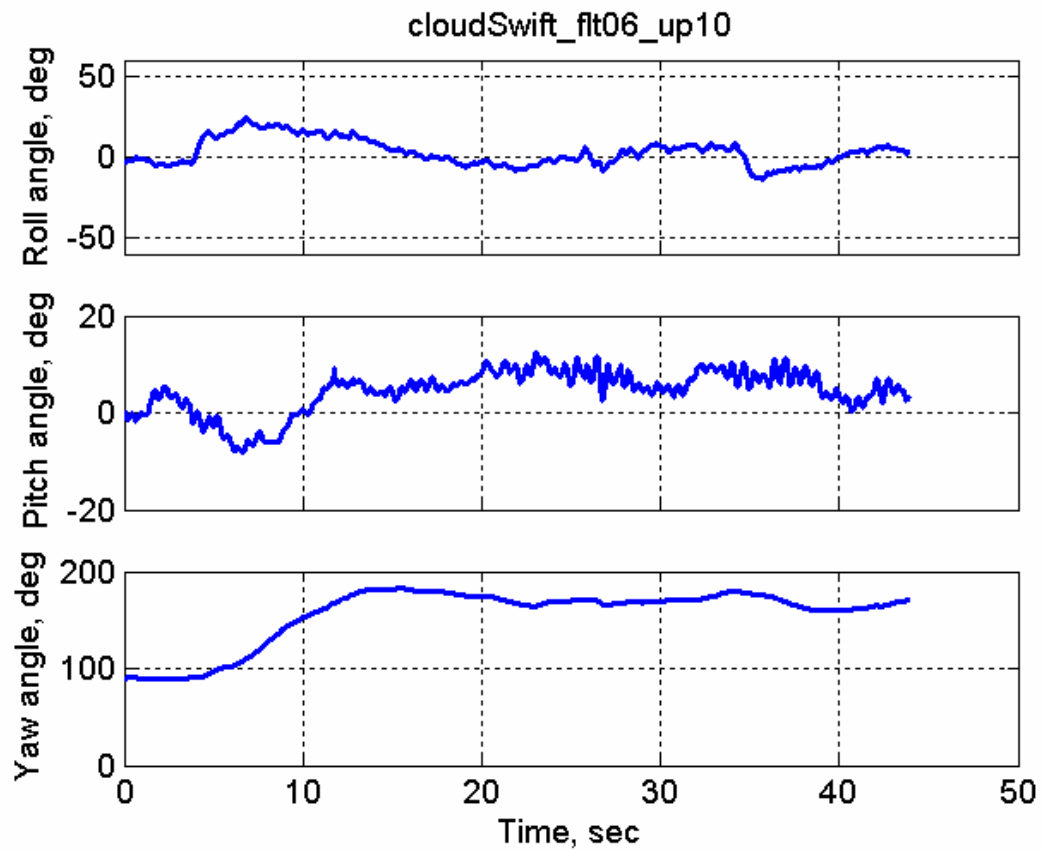


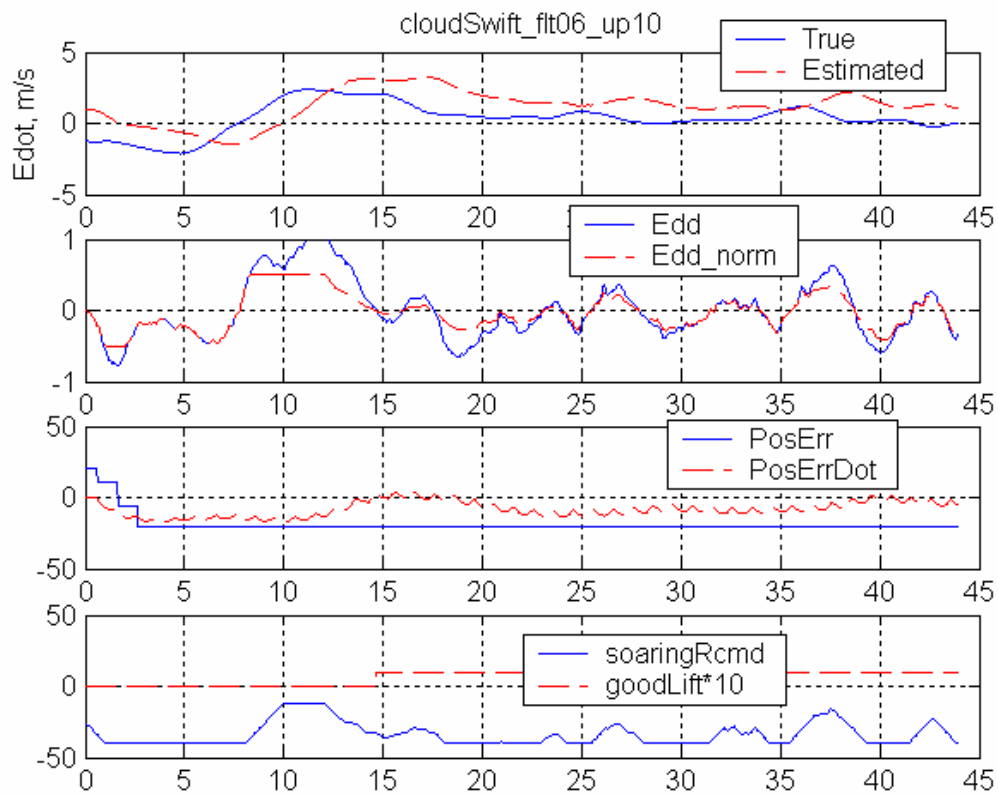
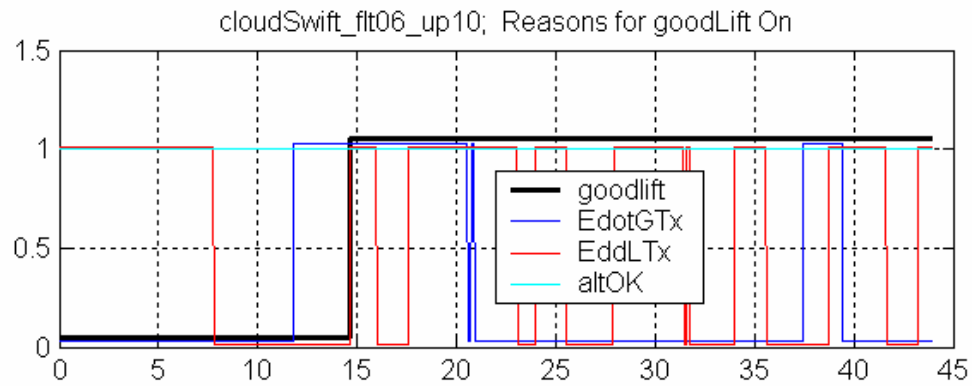


Flight 6, updraft 10



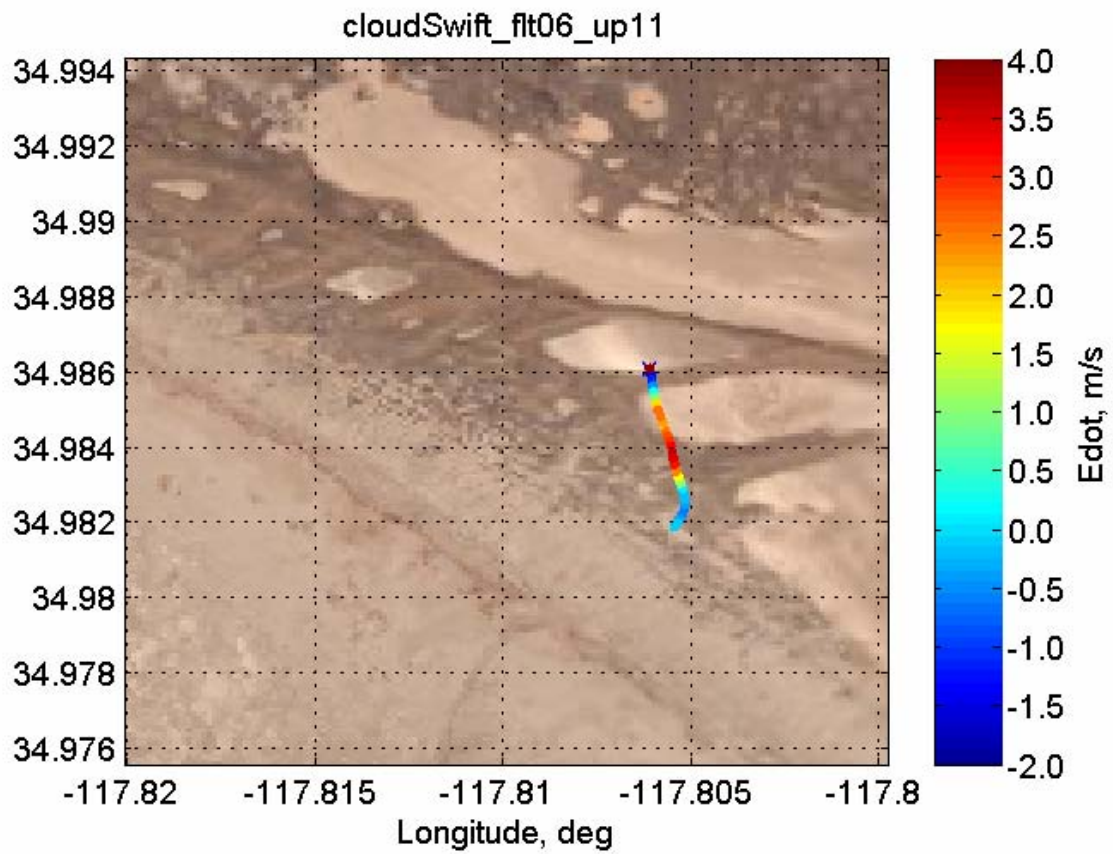


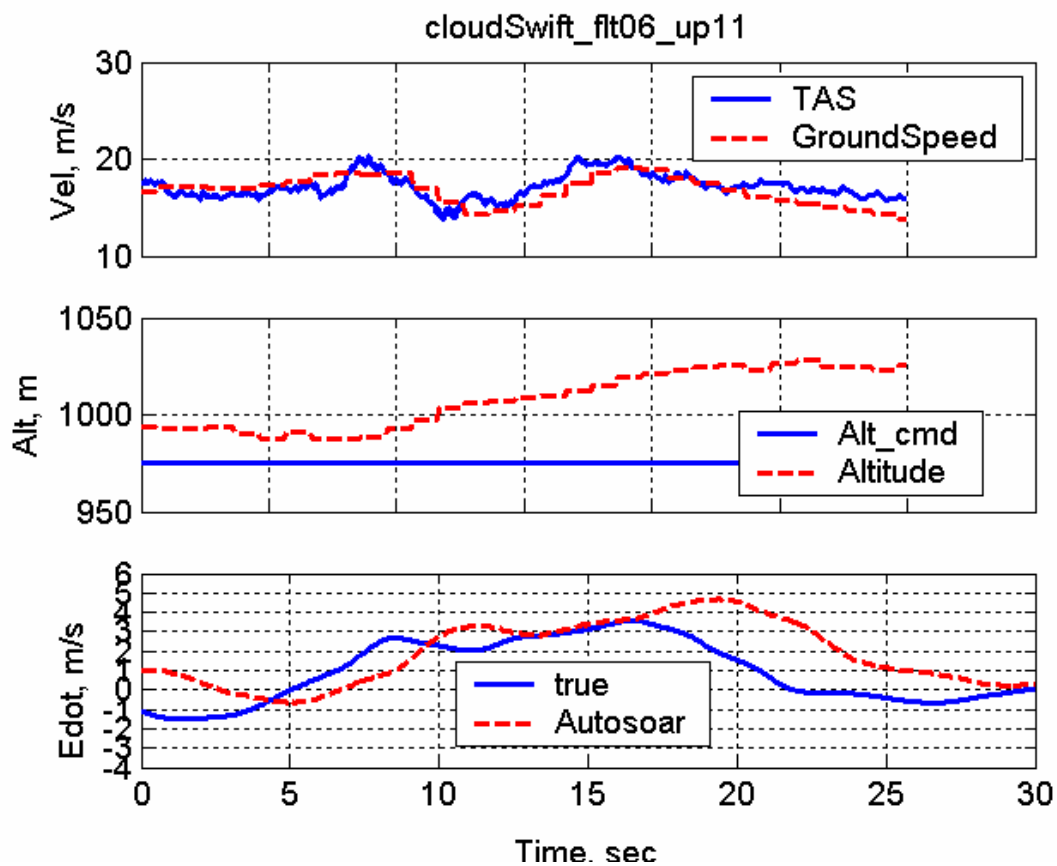
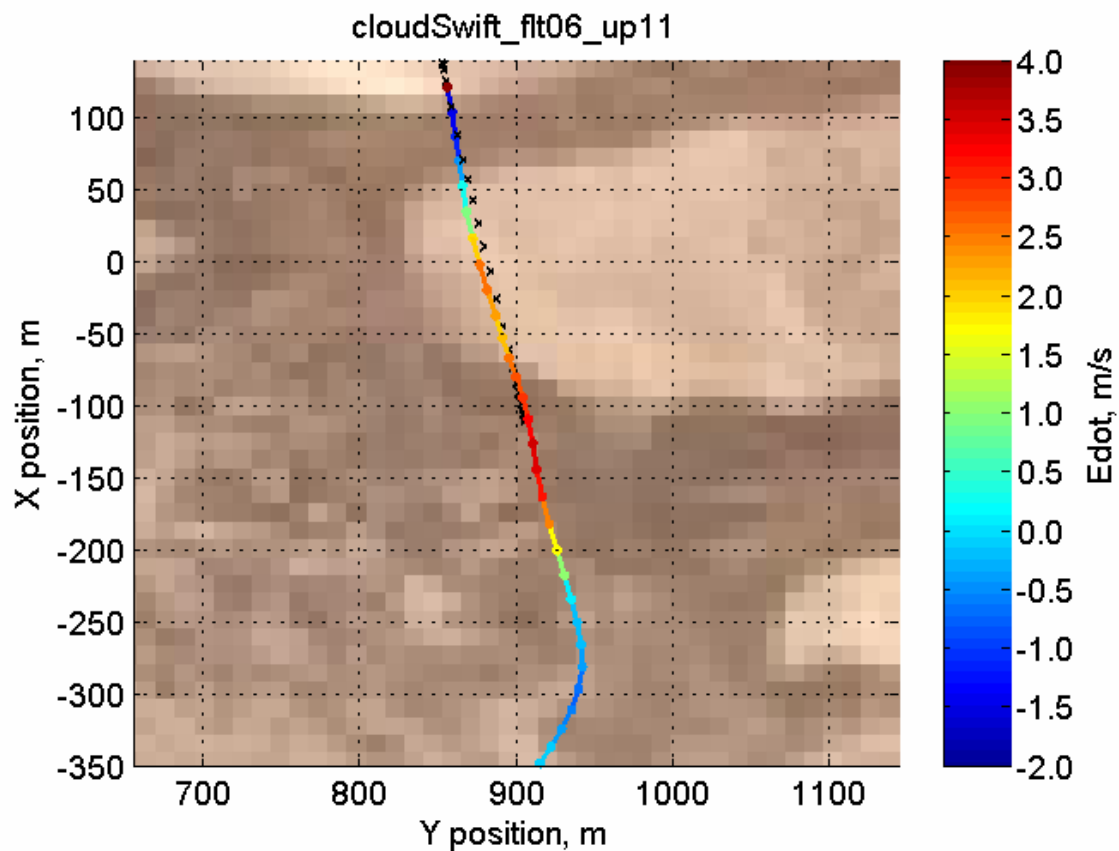


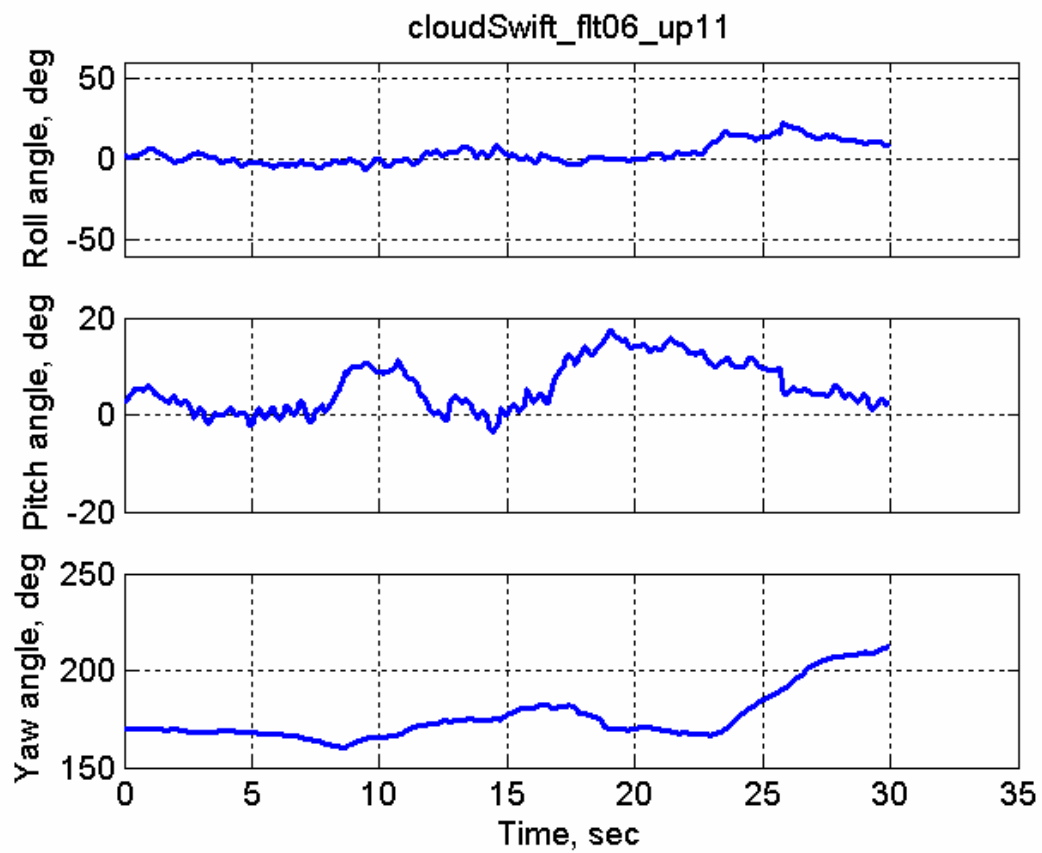
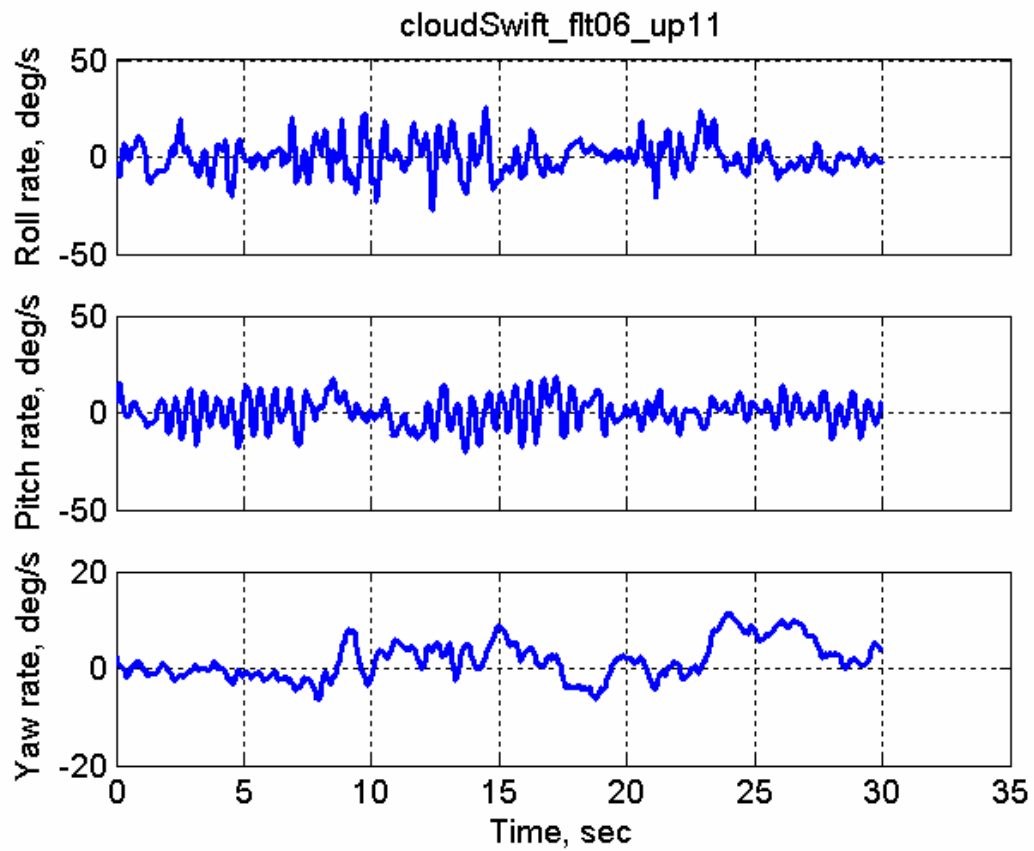


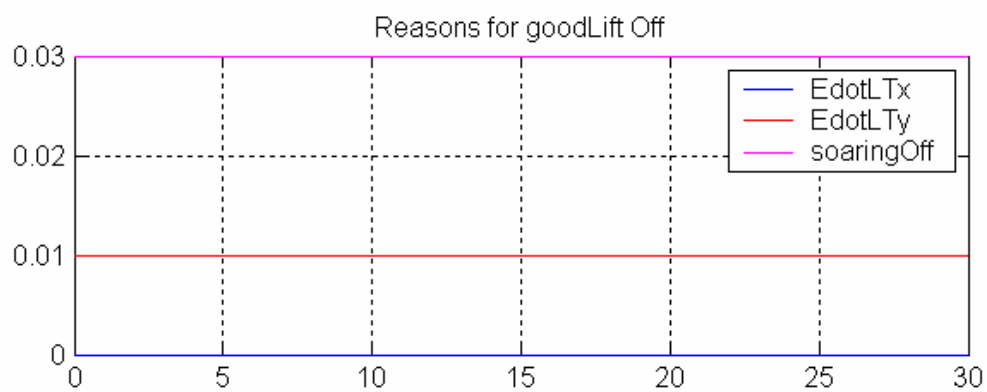
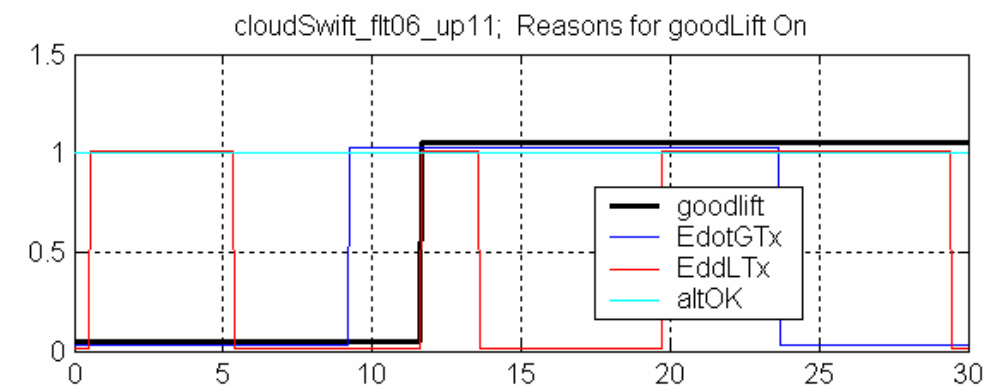
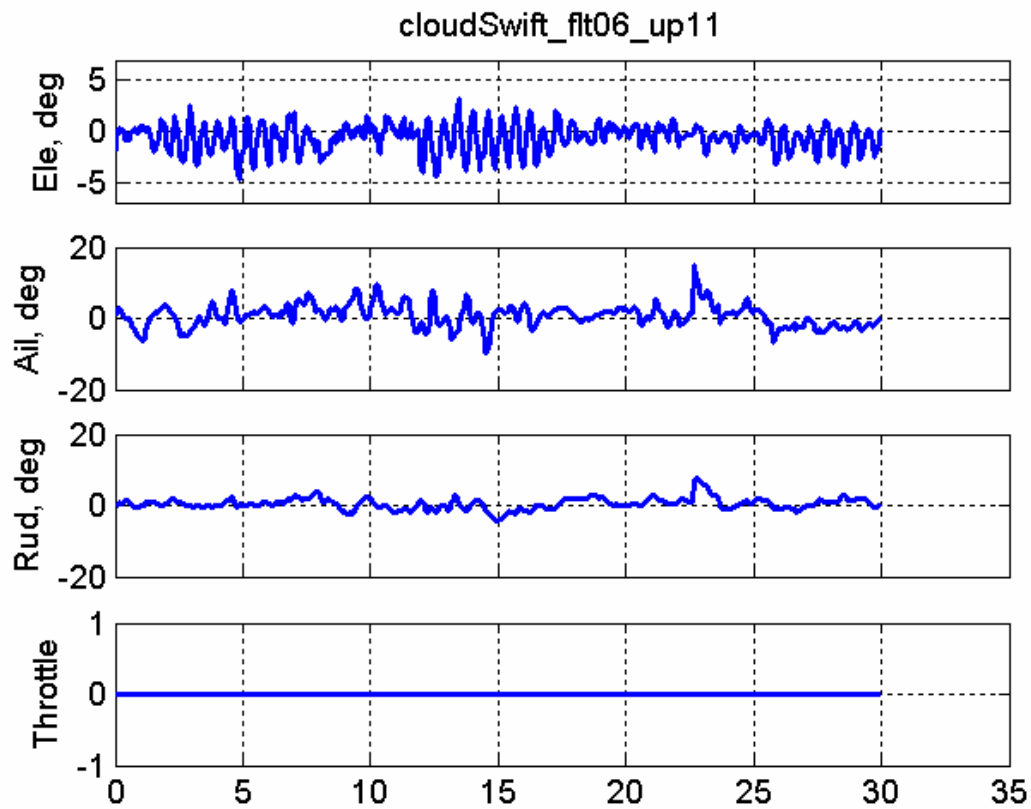
Flight 6, updraft 11

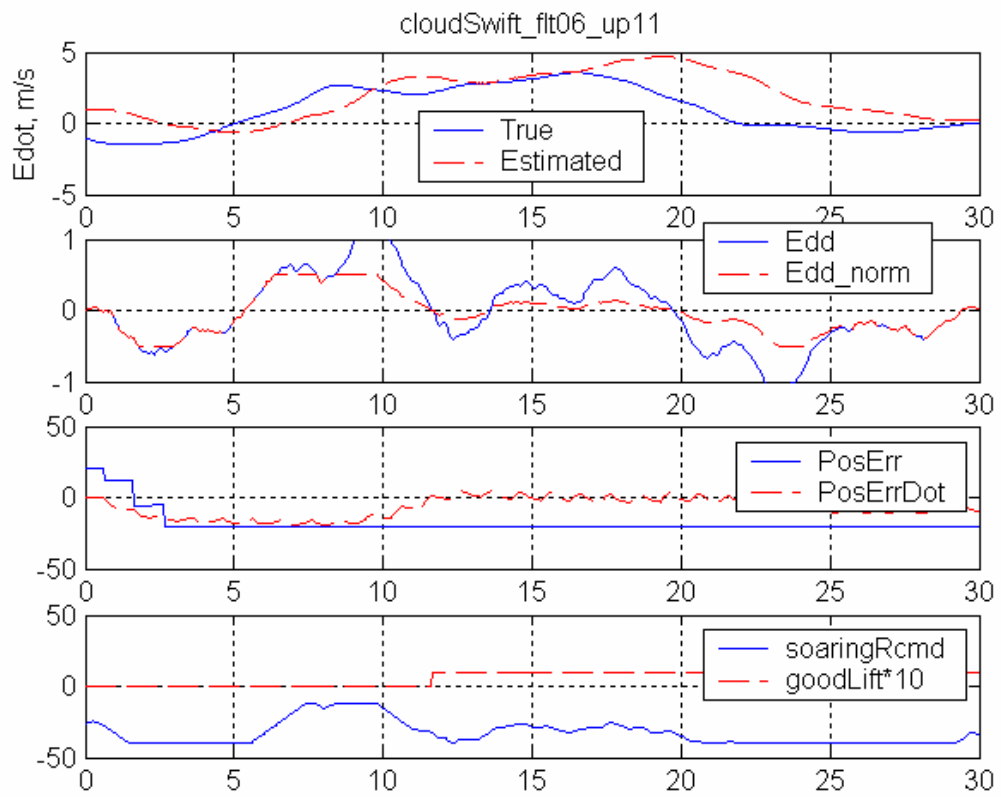
A strong updraft with a double peak shape. Note the false change in pitch angle.





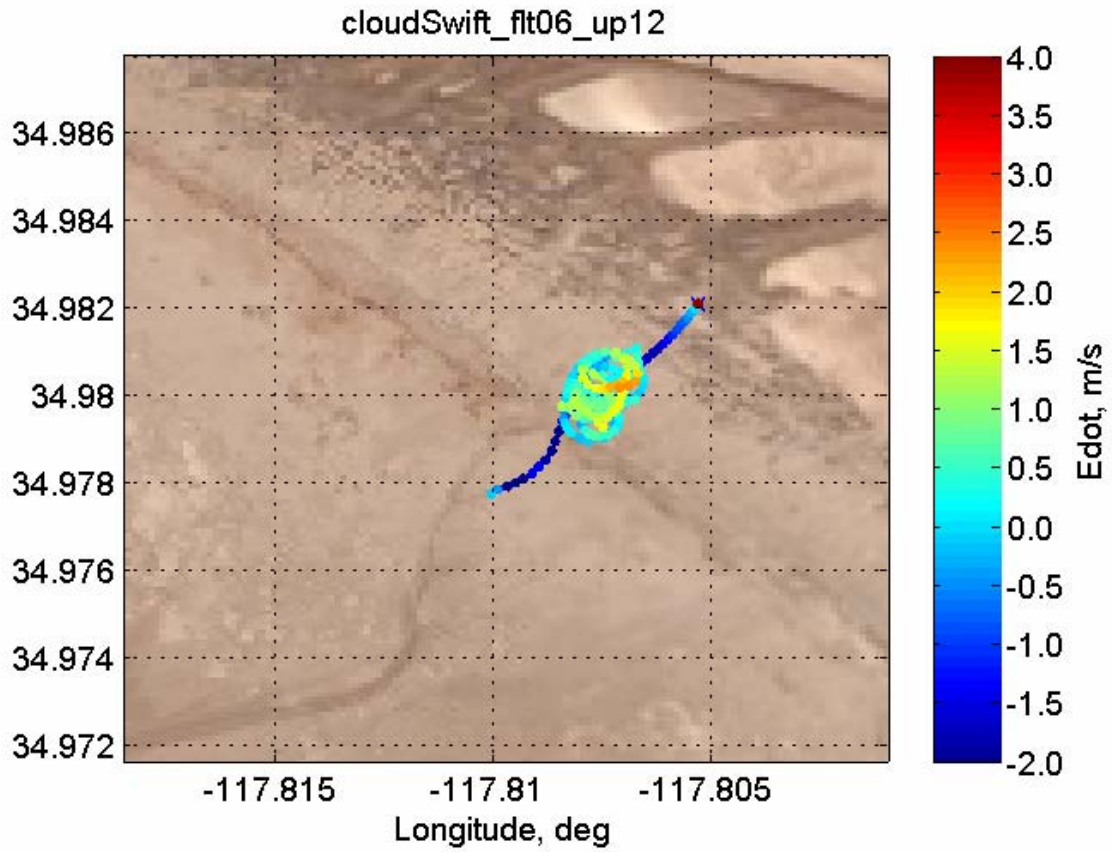


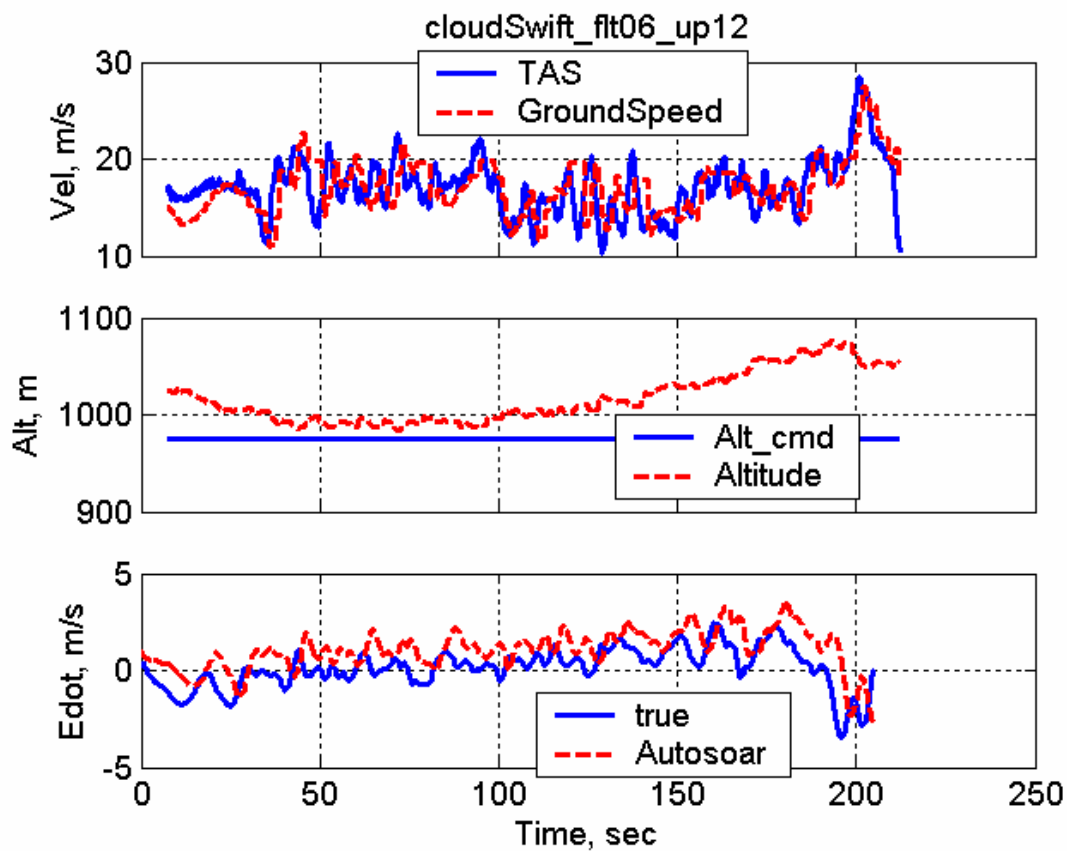
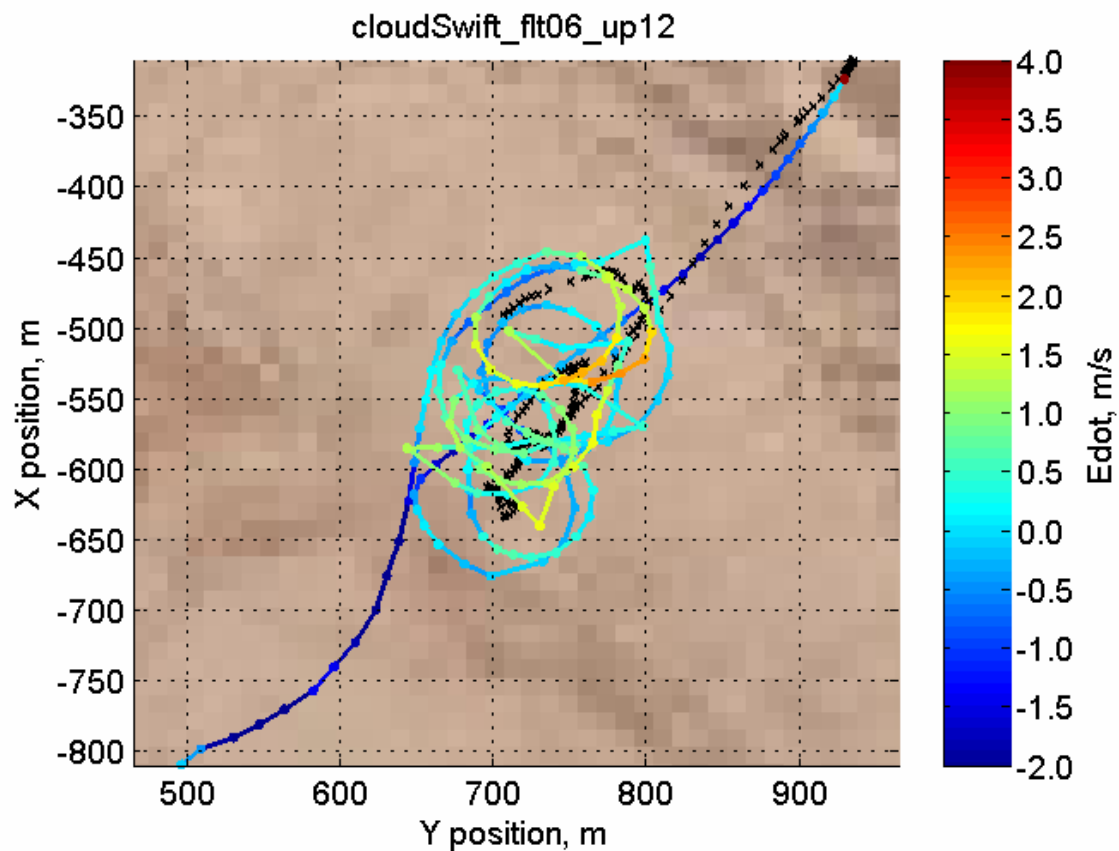


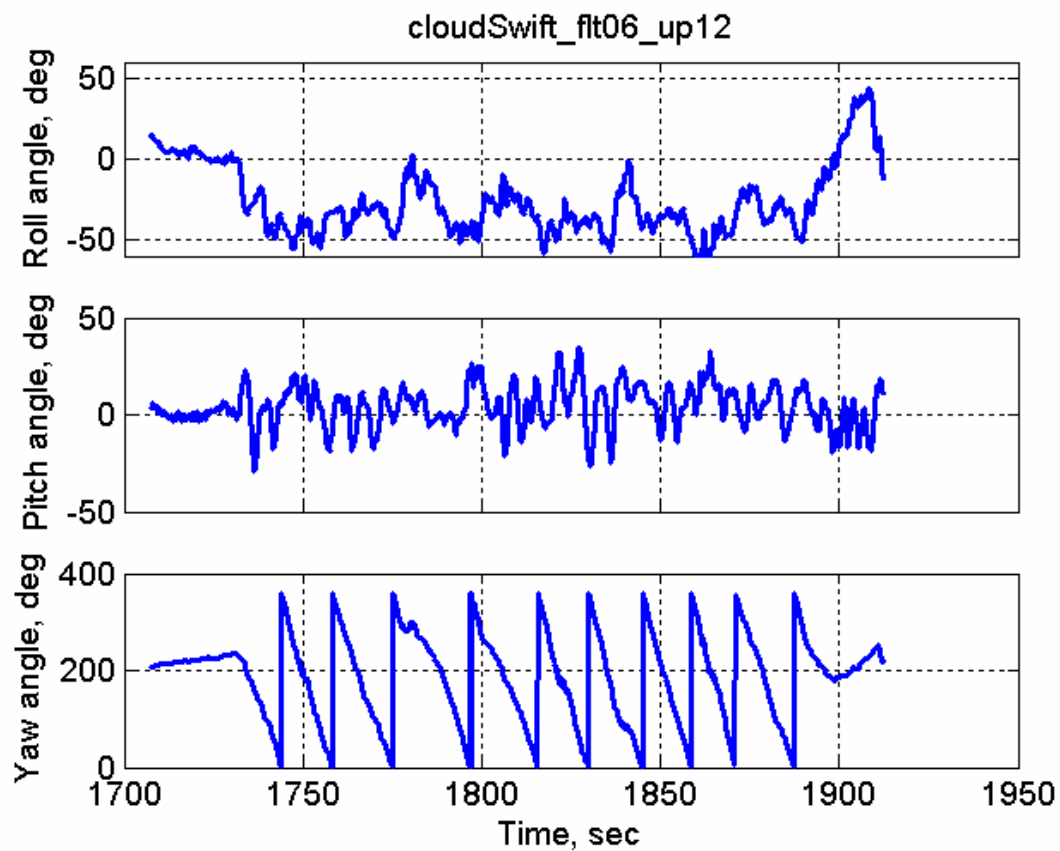
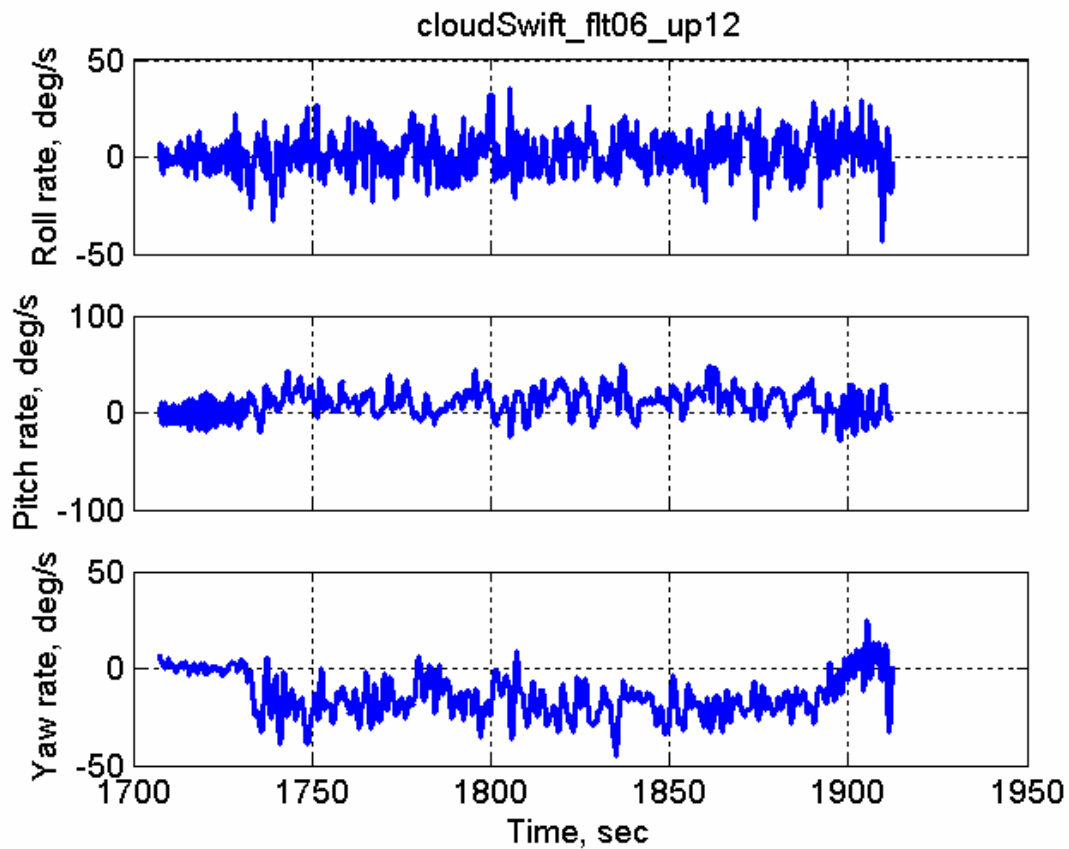


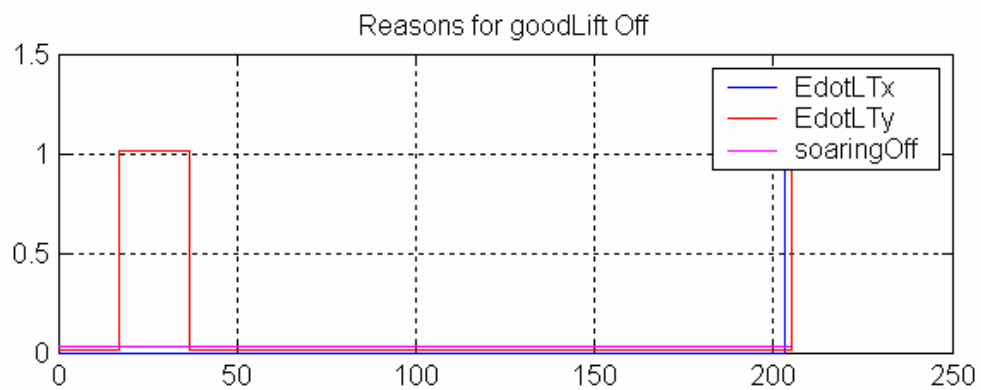
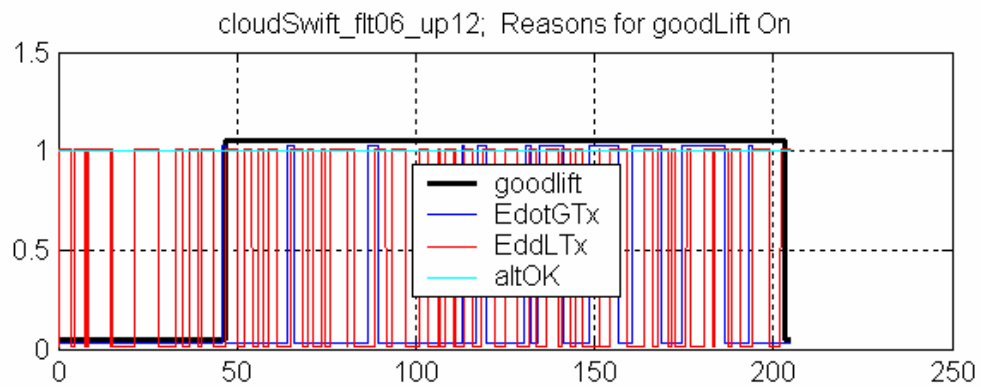
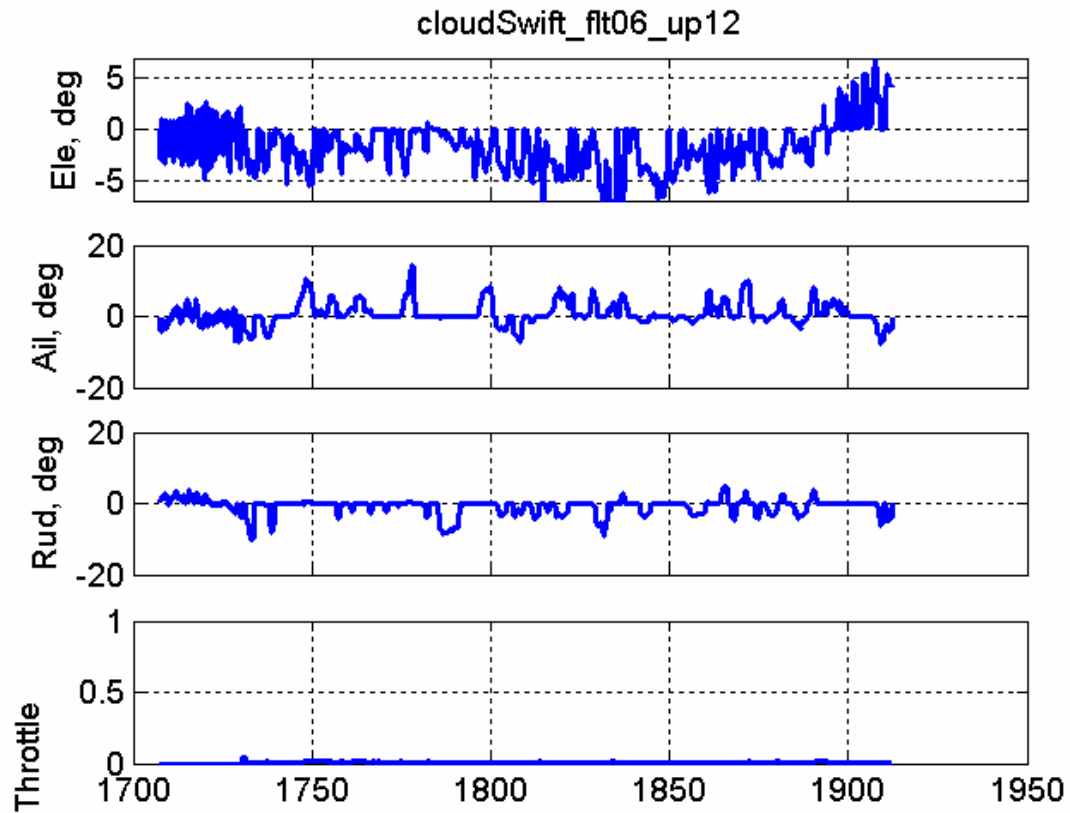
Flight 6, updraft 12

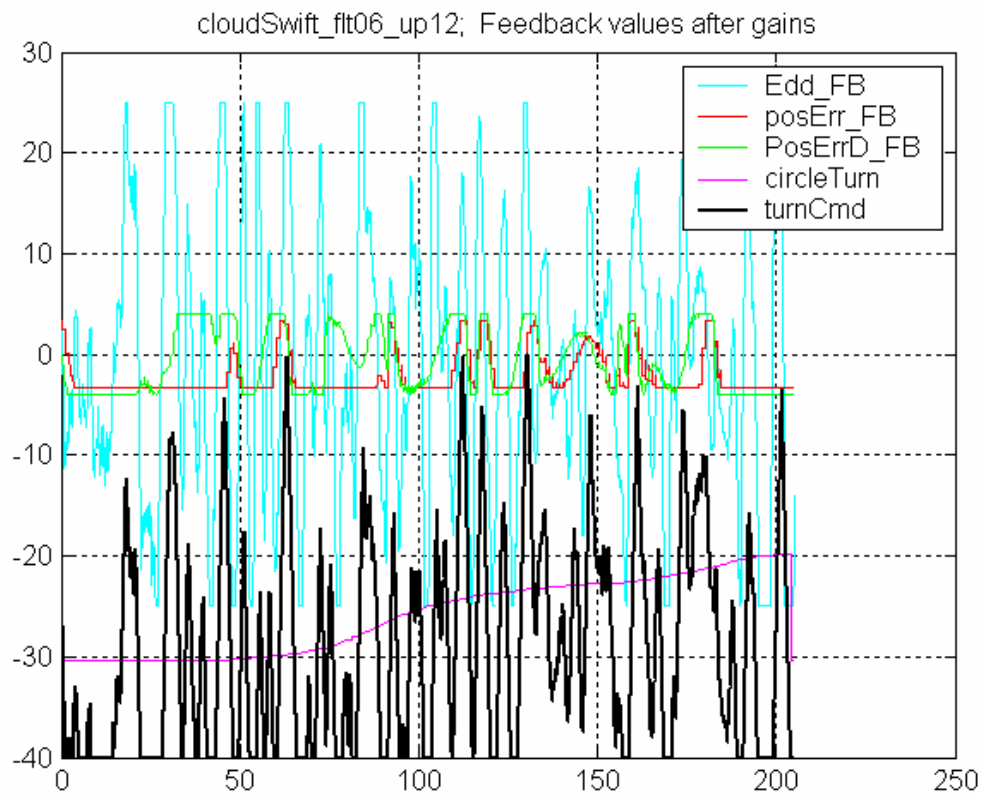
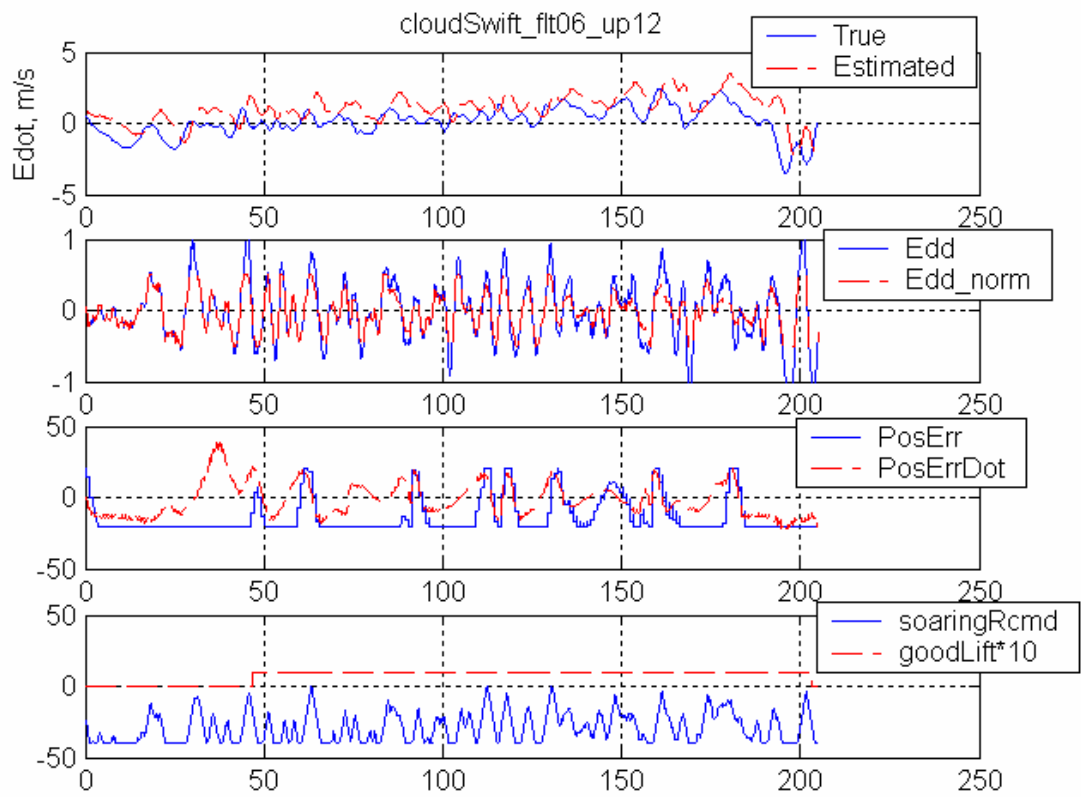
The pilot soared in this thermal to give more data for tuning the soaring algorithms.







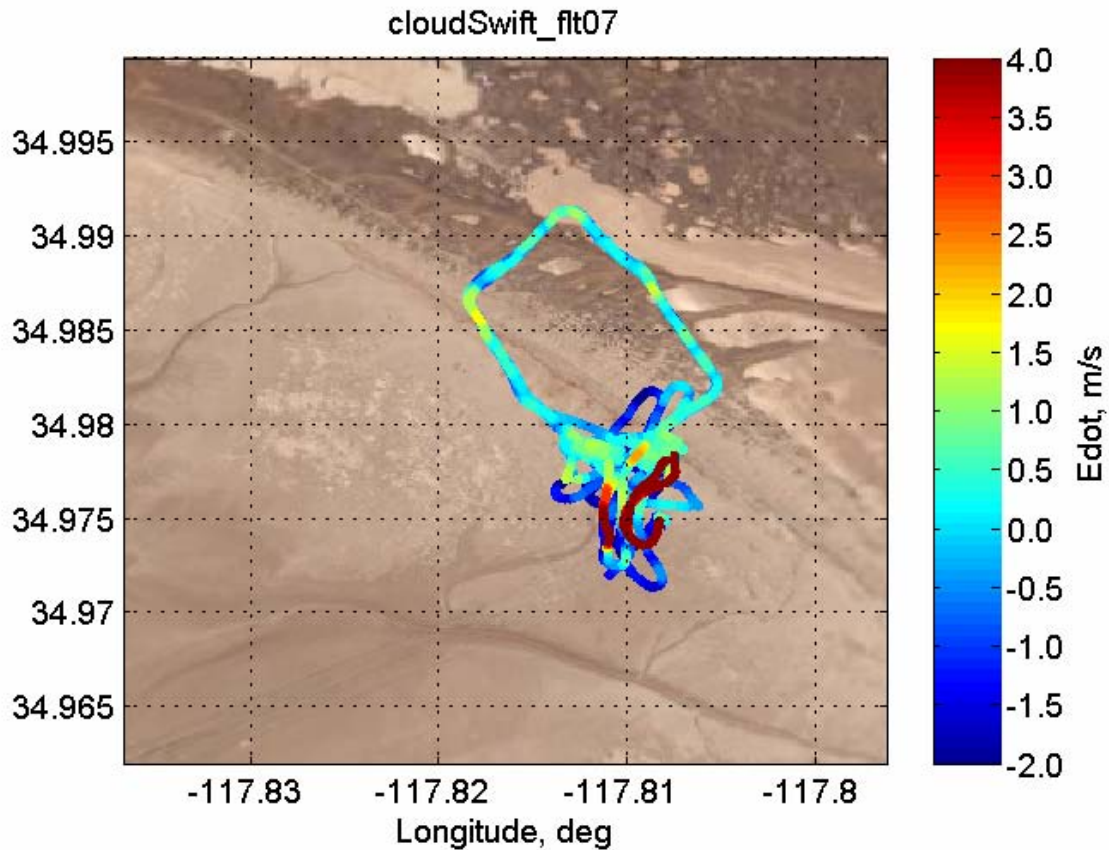


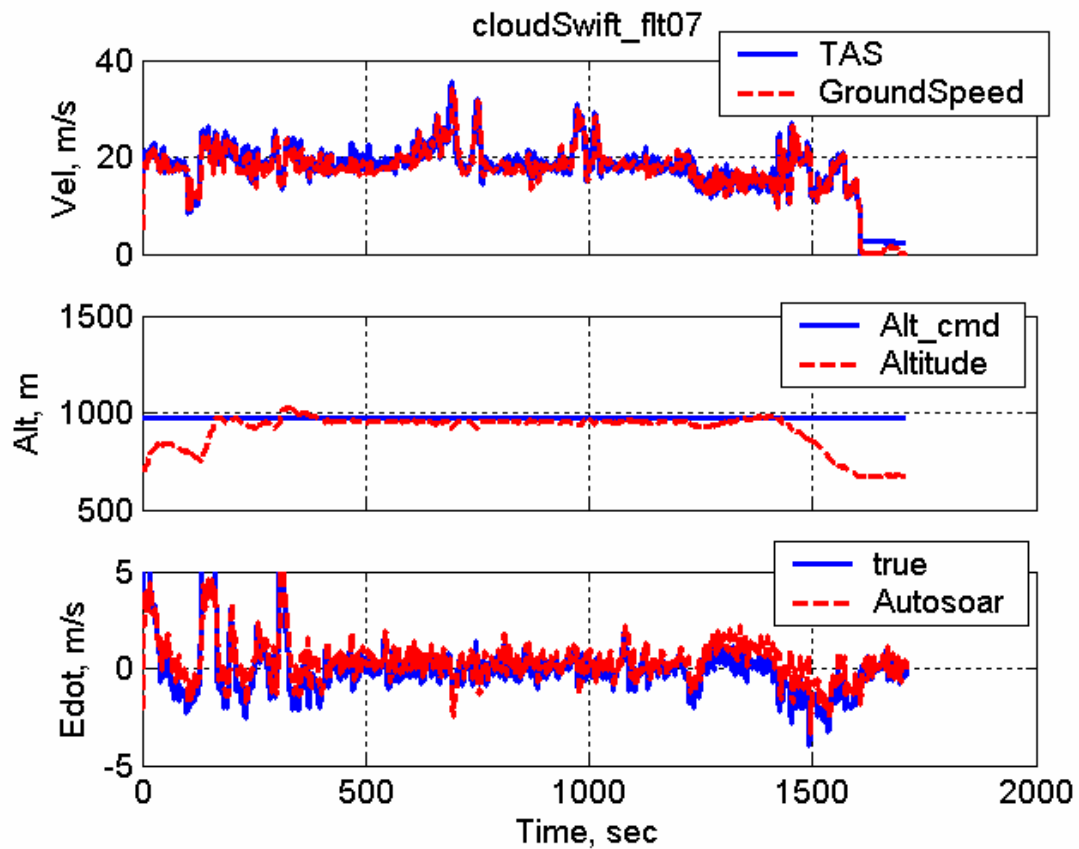
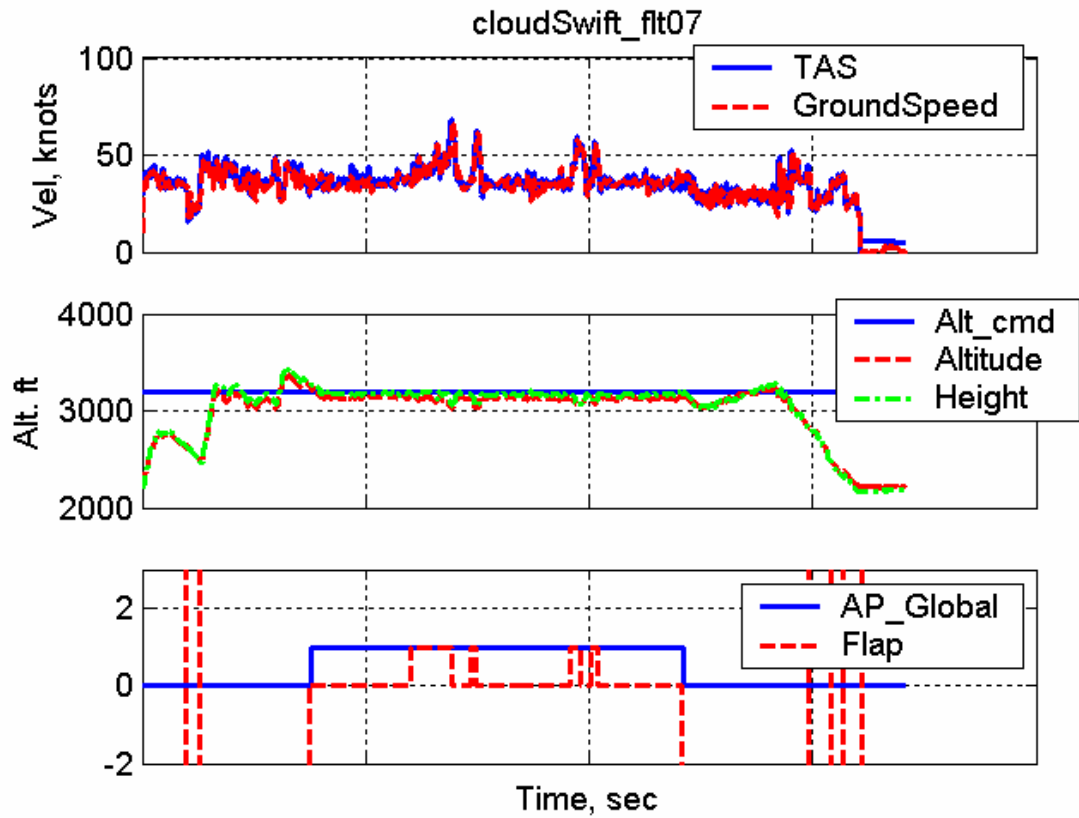


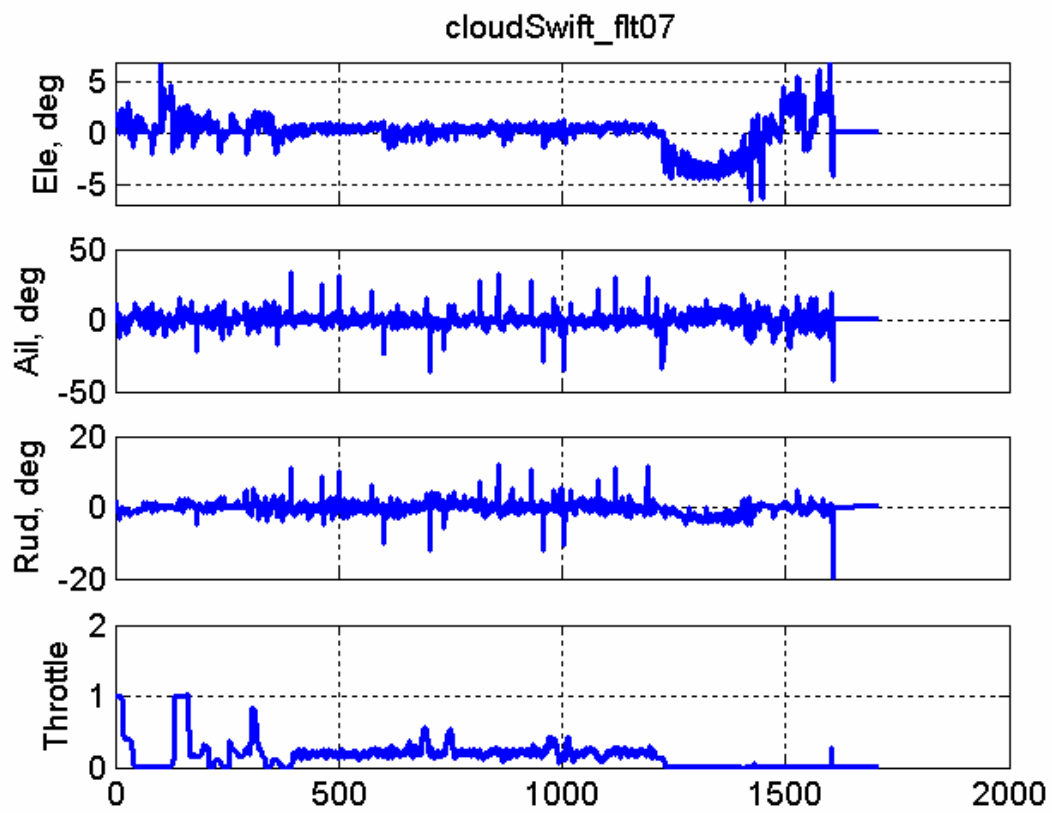
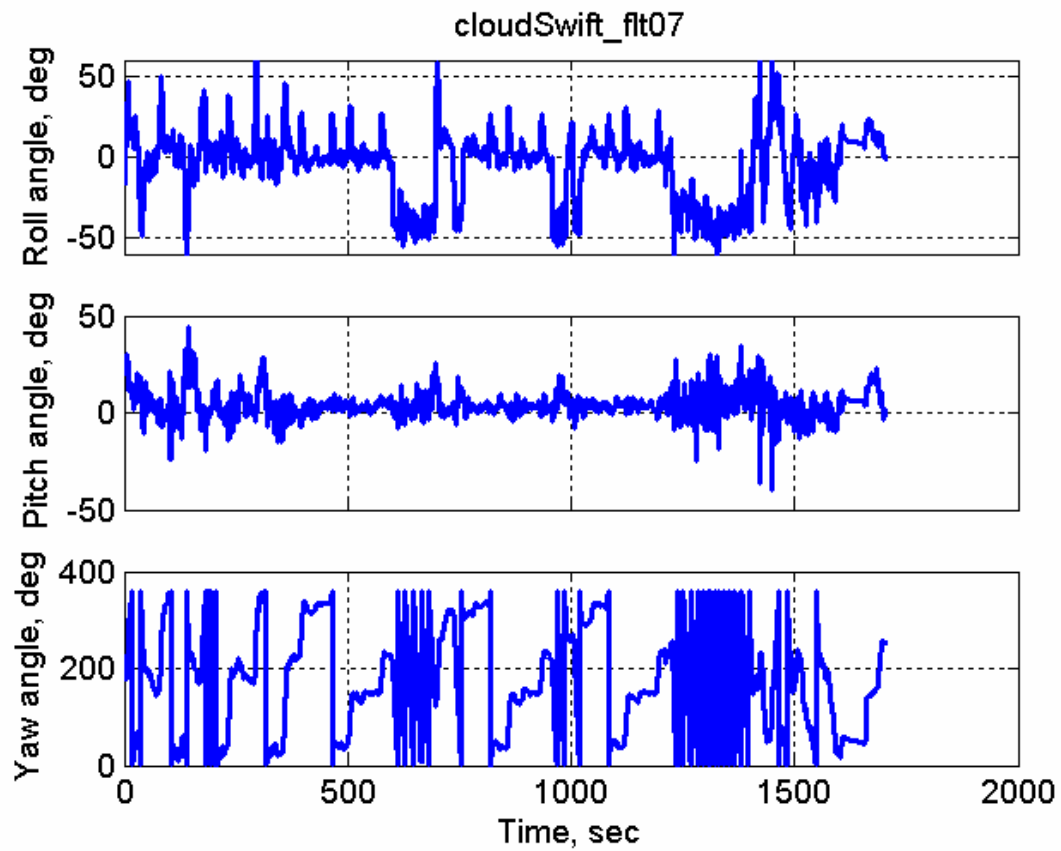
Flight 7

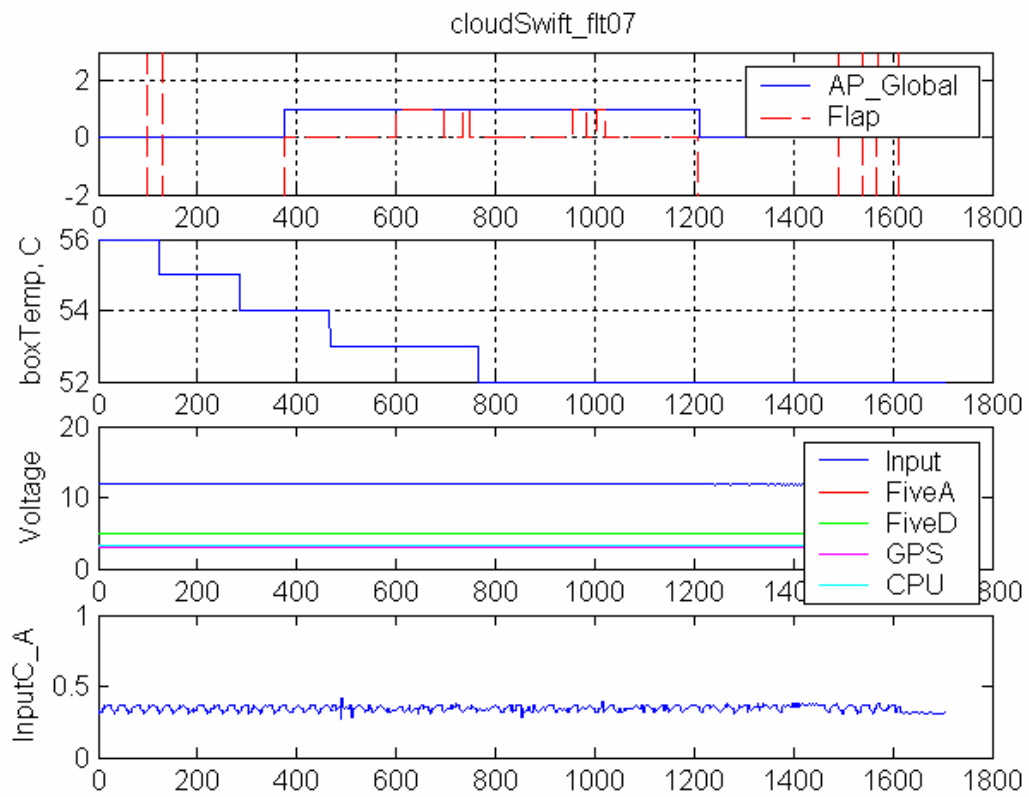
Flight 7 was used to test the autonomous soaring algorithms. The mode logic was set to trigger on much weaker thermals to fix the problem encountered in flight 6. As a result, the aircraft spends much of flight 7 circling in weak lift with the motor on until it decides that the thermal is too weak and moves on. This problem was compounded by poor tracking by the Piccolo inner loop velocity controller during soaring. Sometimes the groundstation operator turned off soaring if the aircraft was not climbing.

Pitch gains were adjusted to remove the pitch oscillations seen in the previous flights.

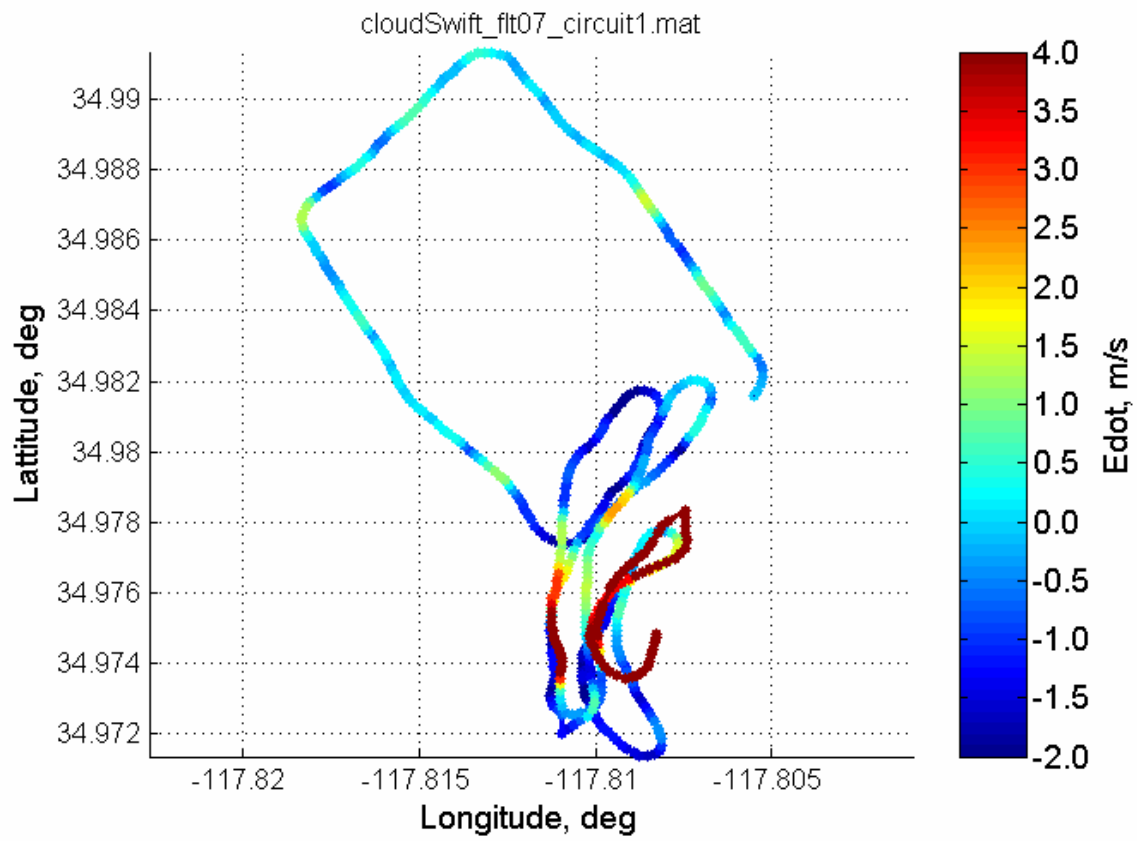


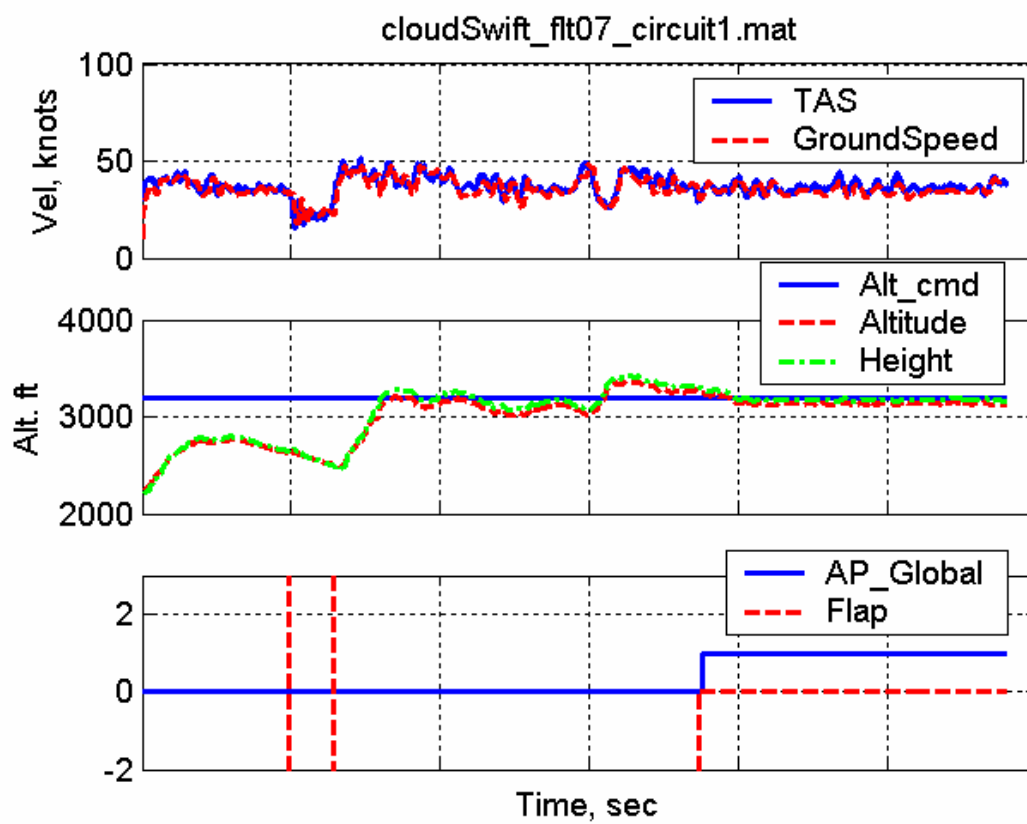
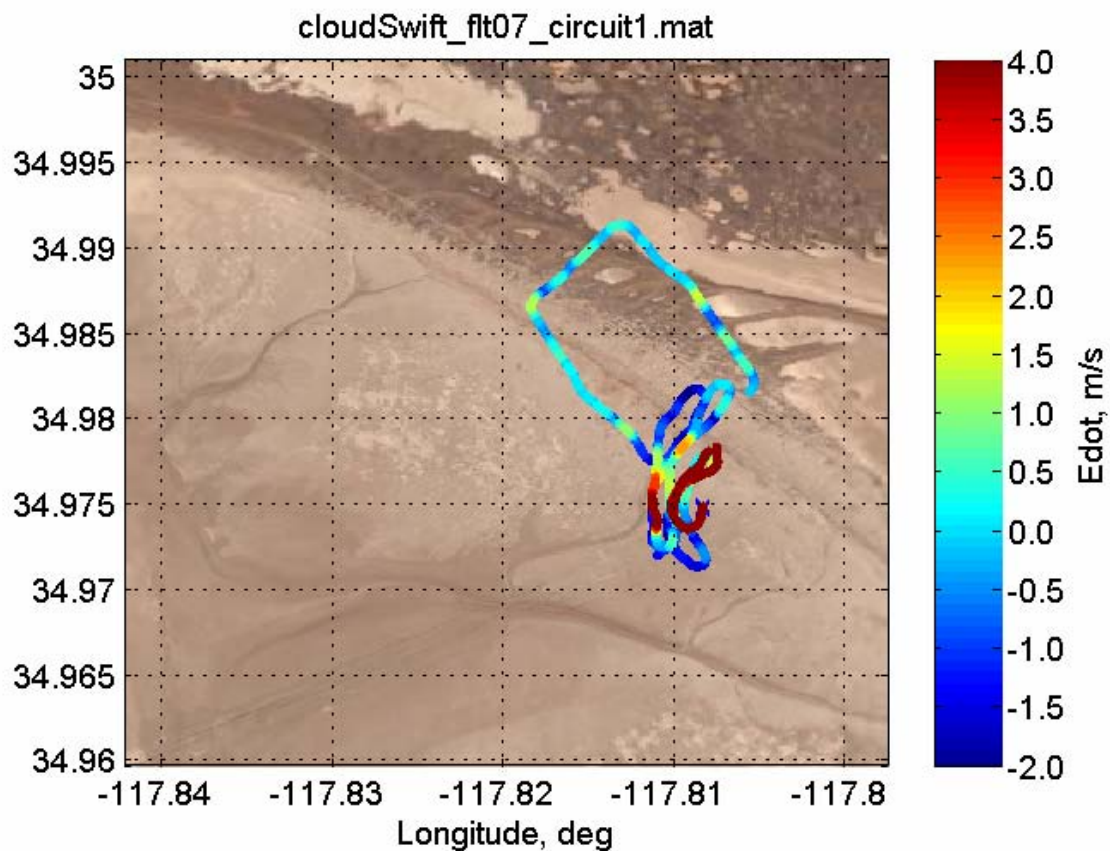


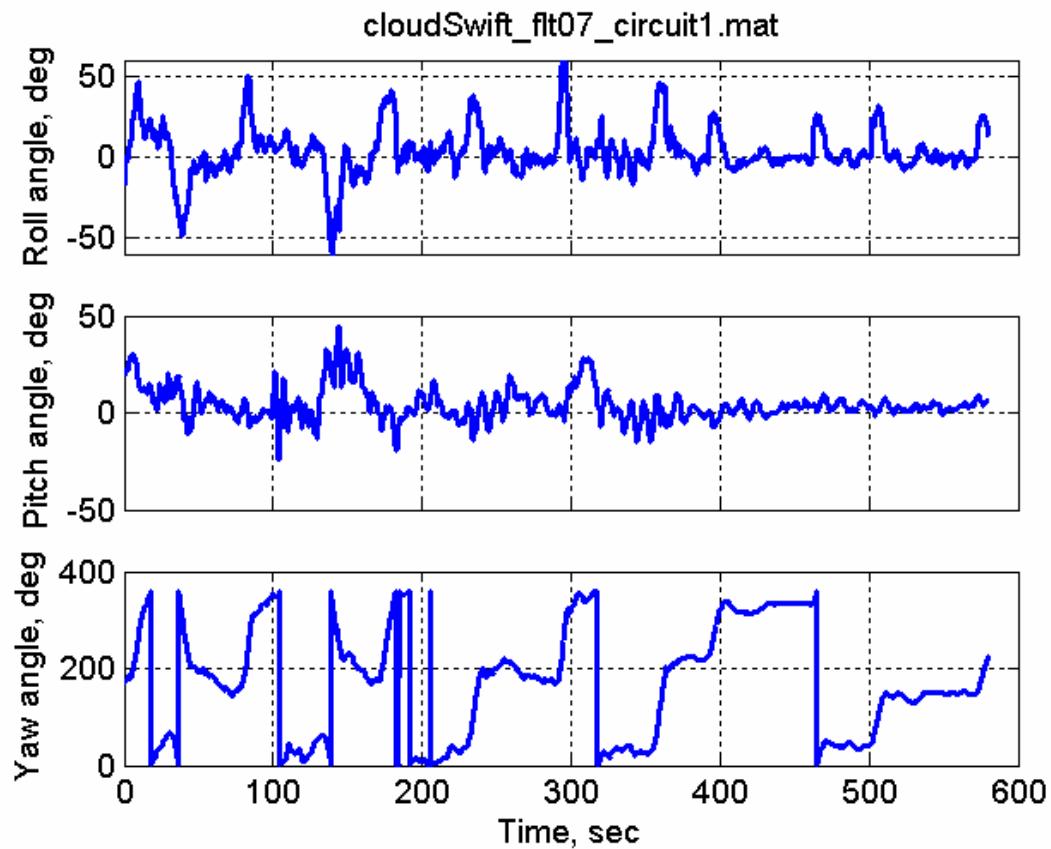
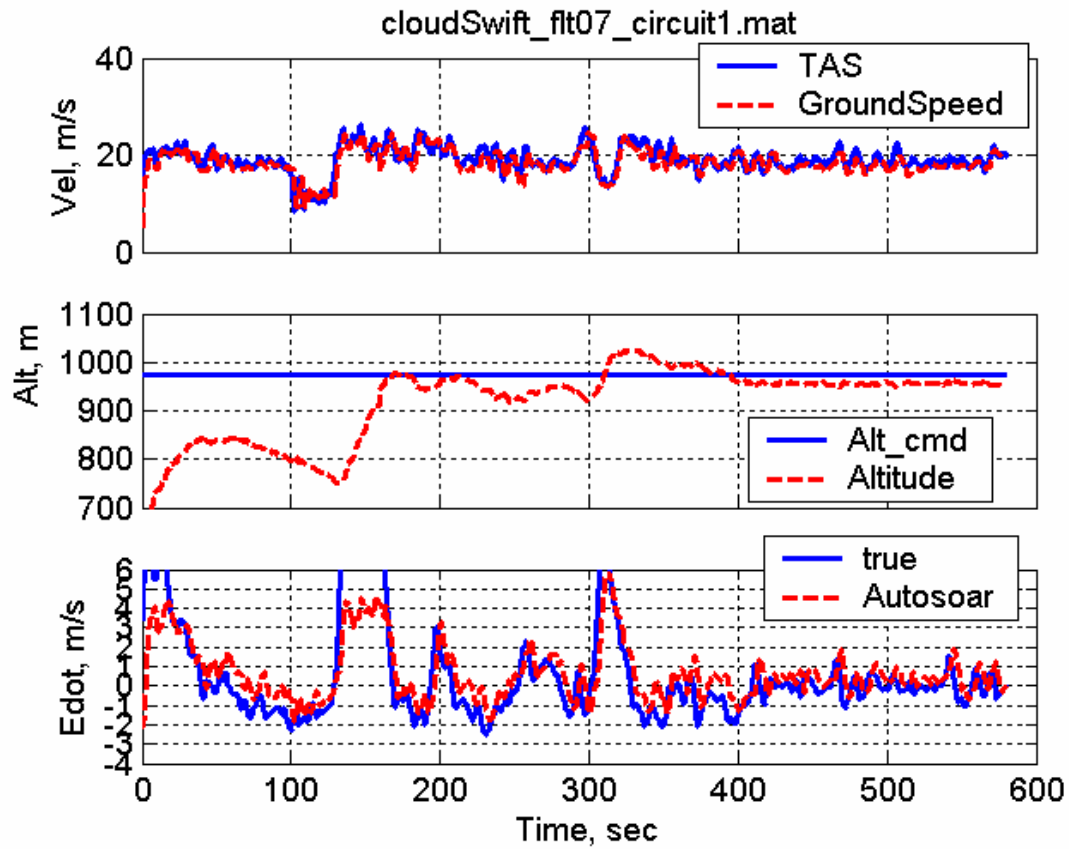




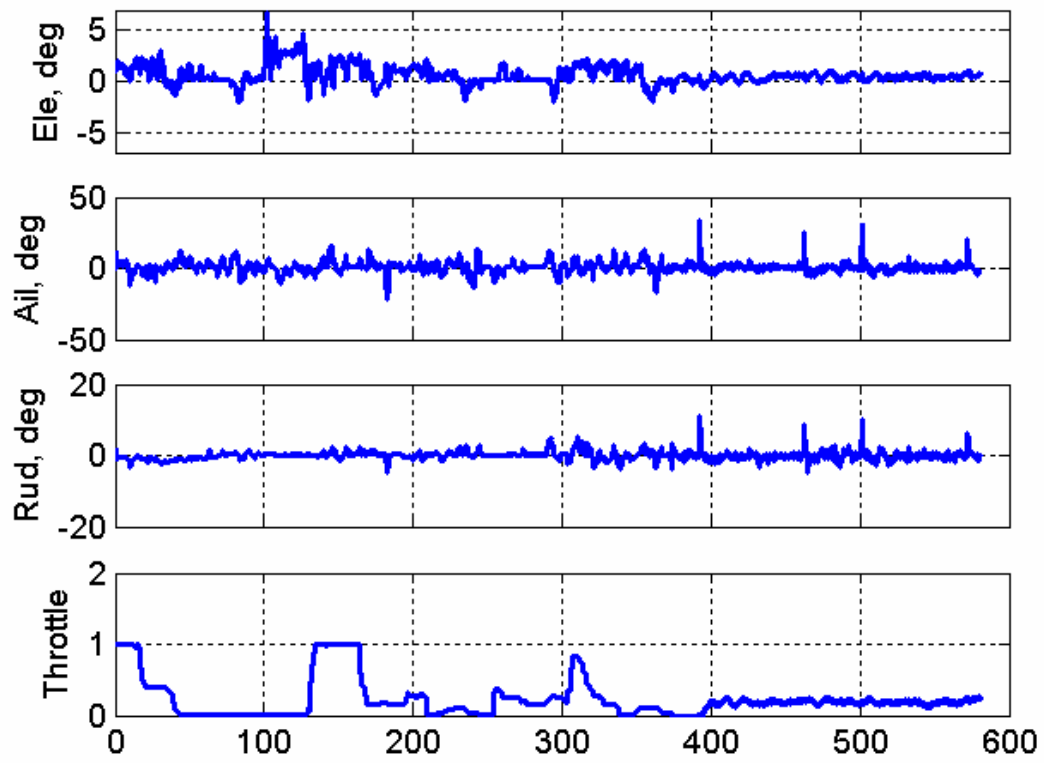
Flight 7, circuit 1





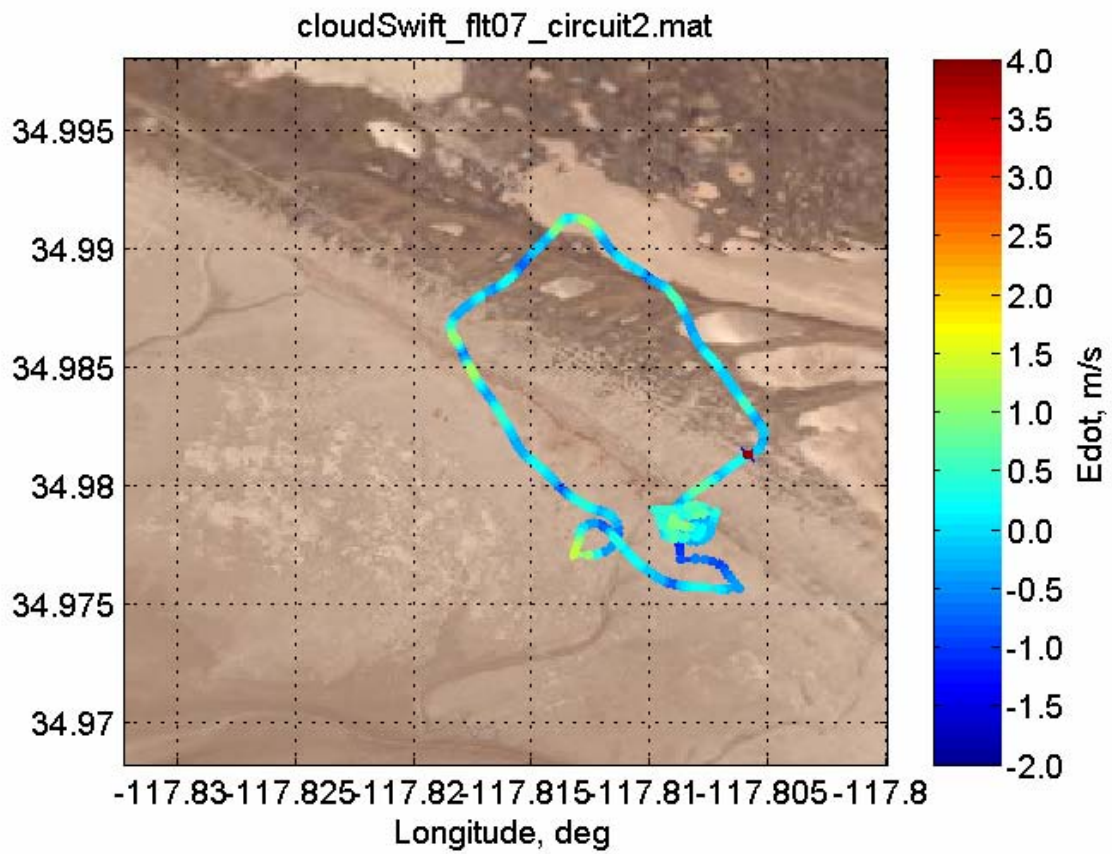


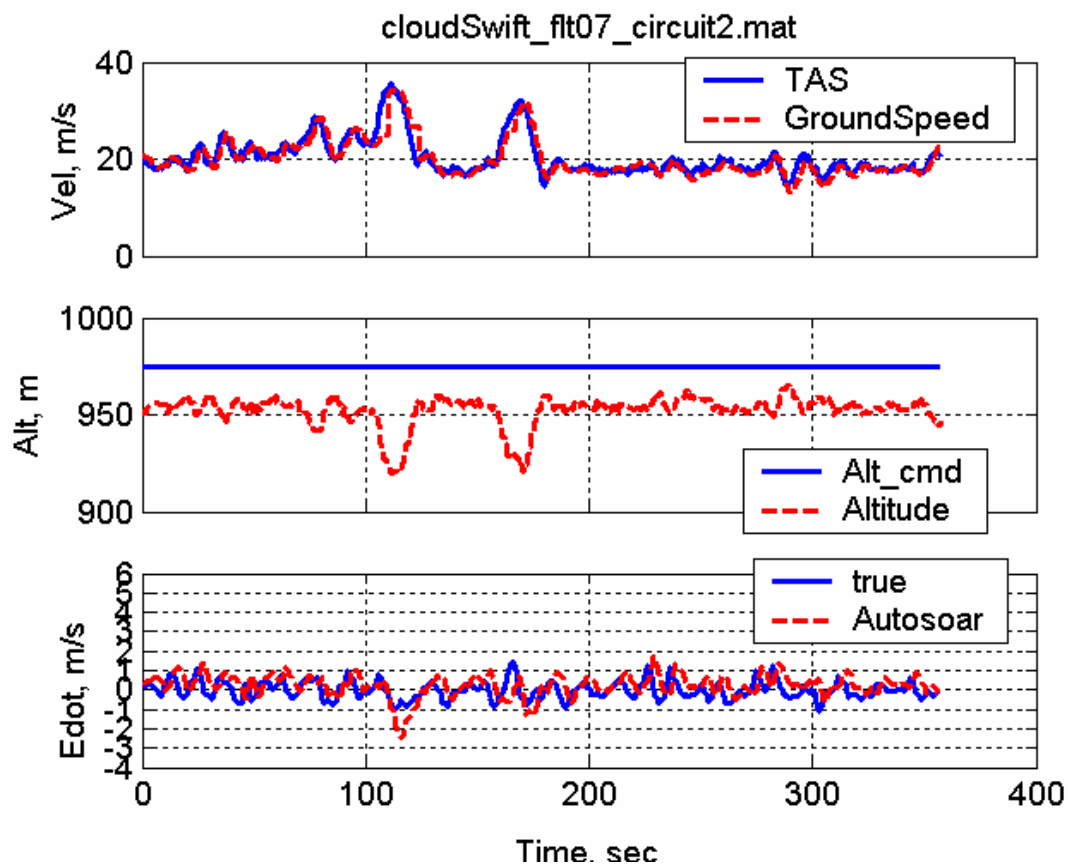
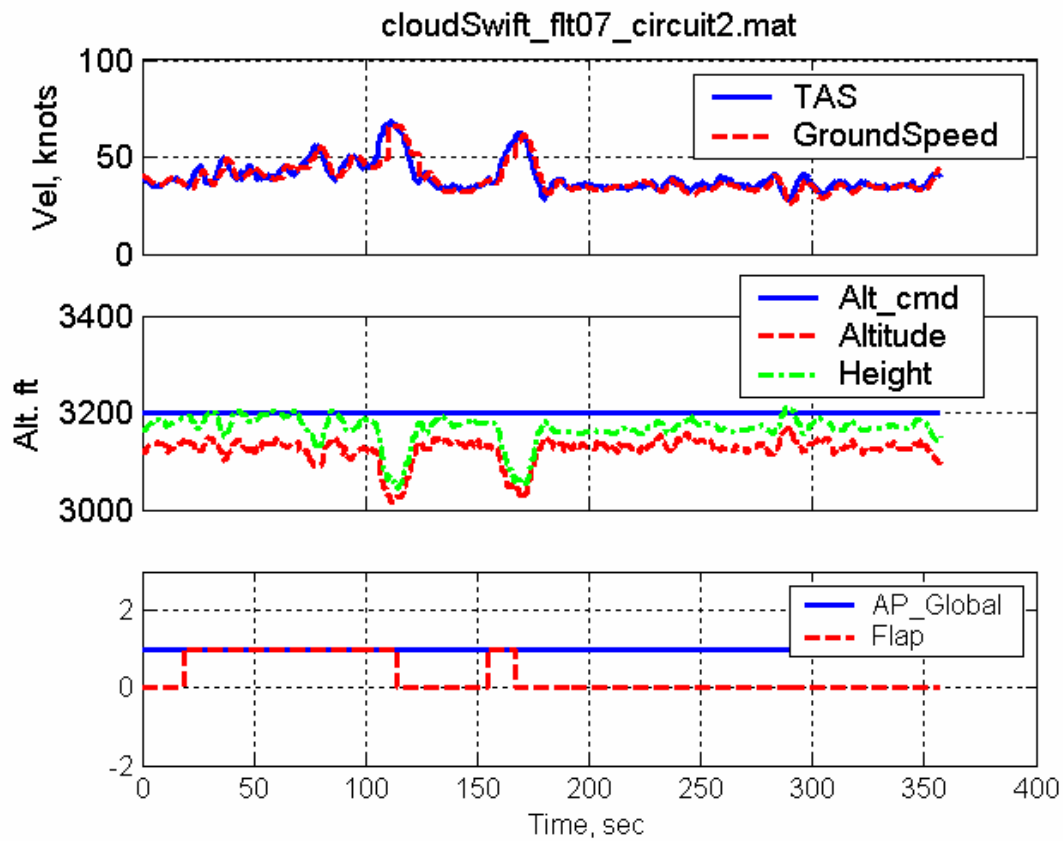
cloudSwift_flt07_circuit1.mat

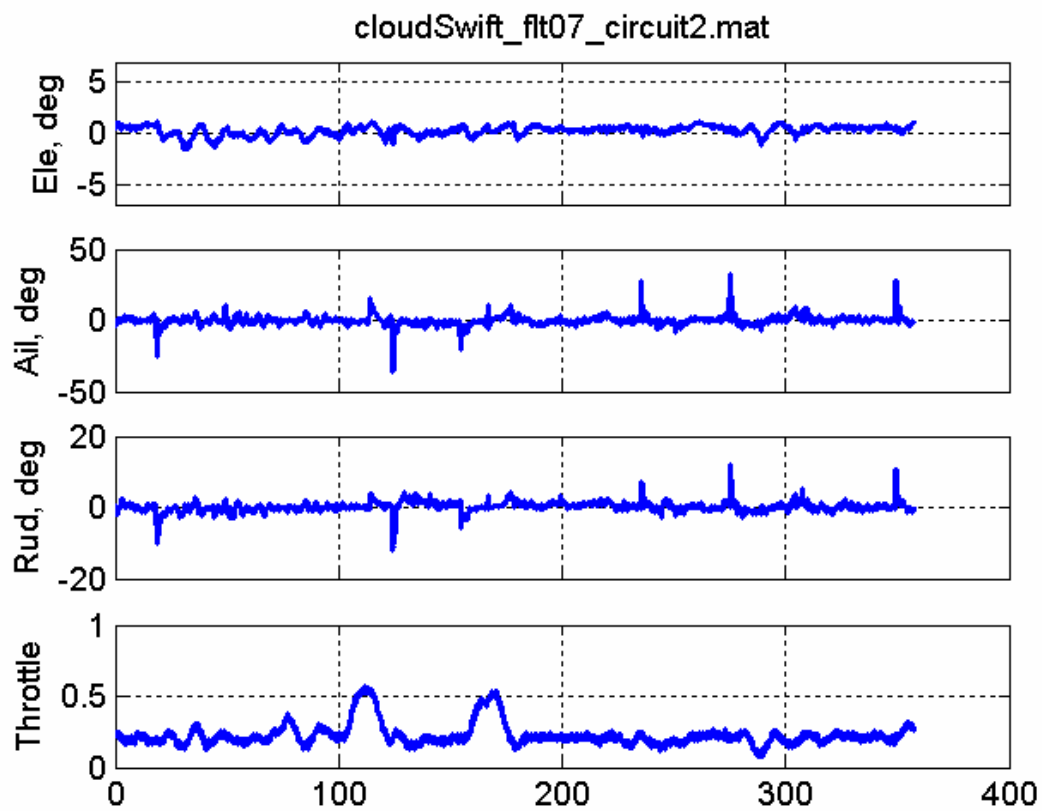
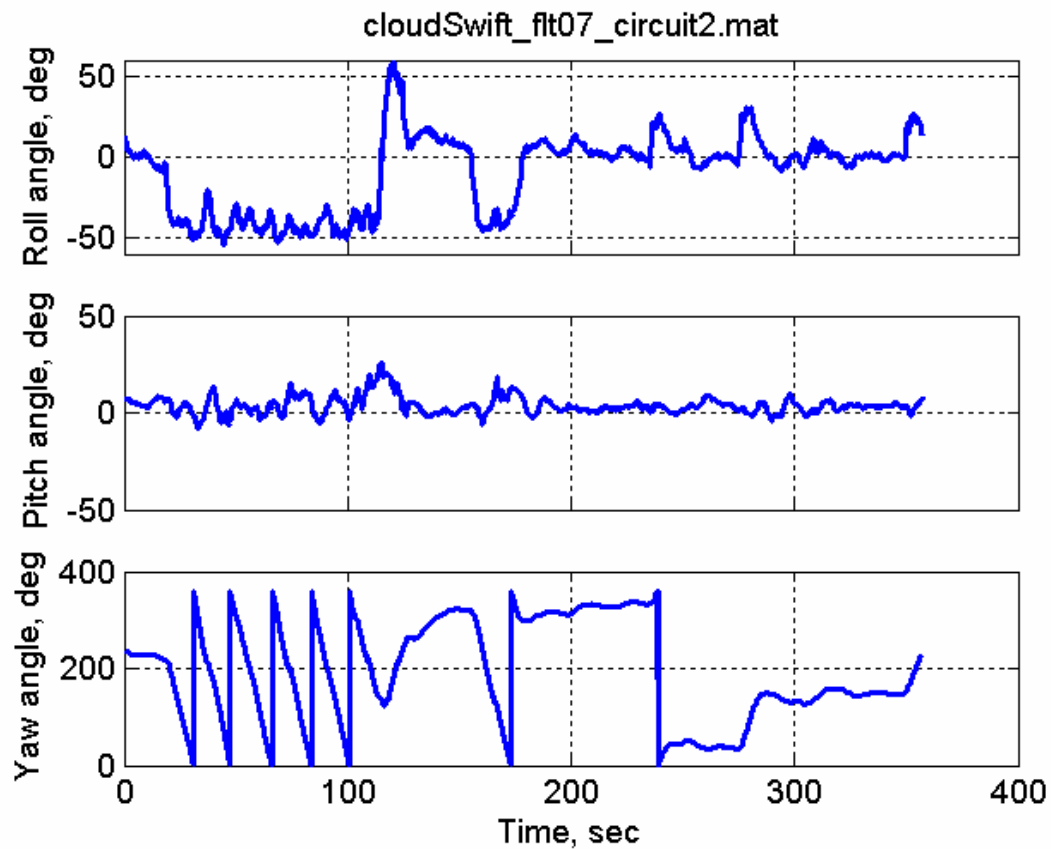


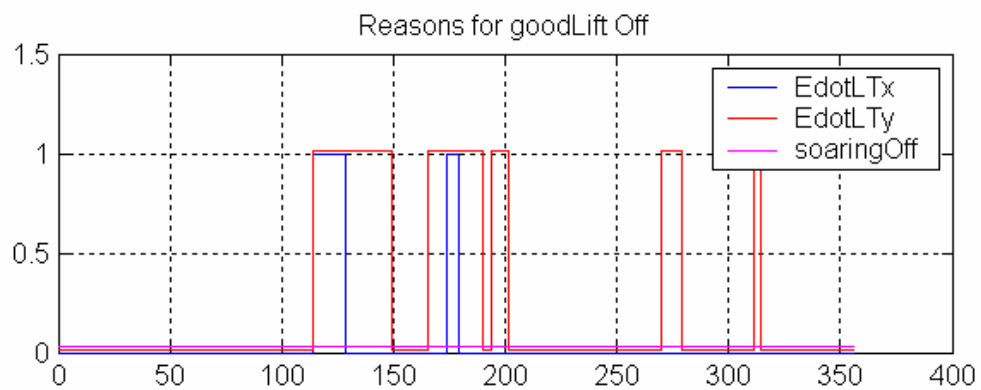
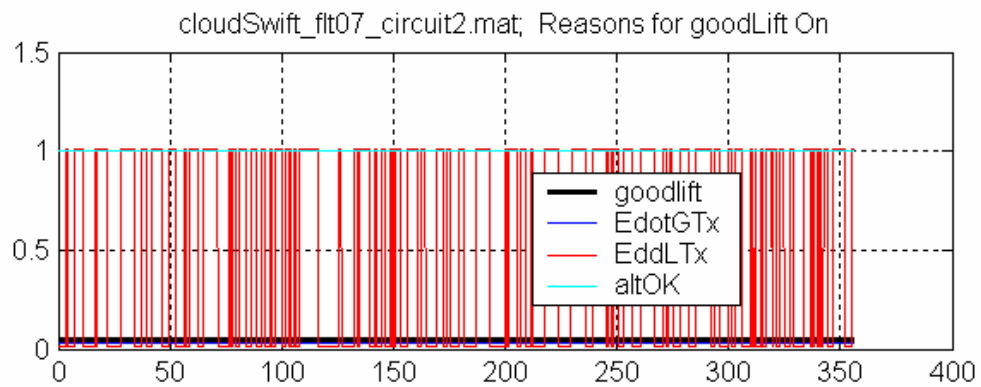
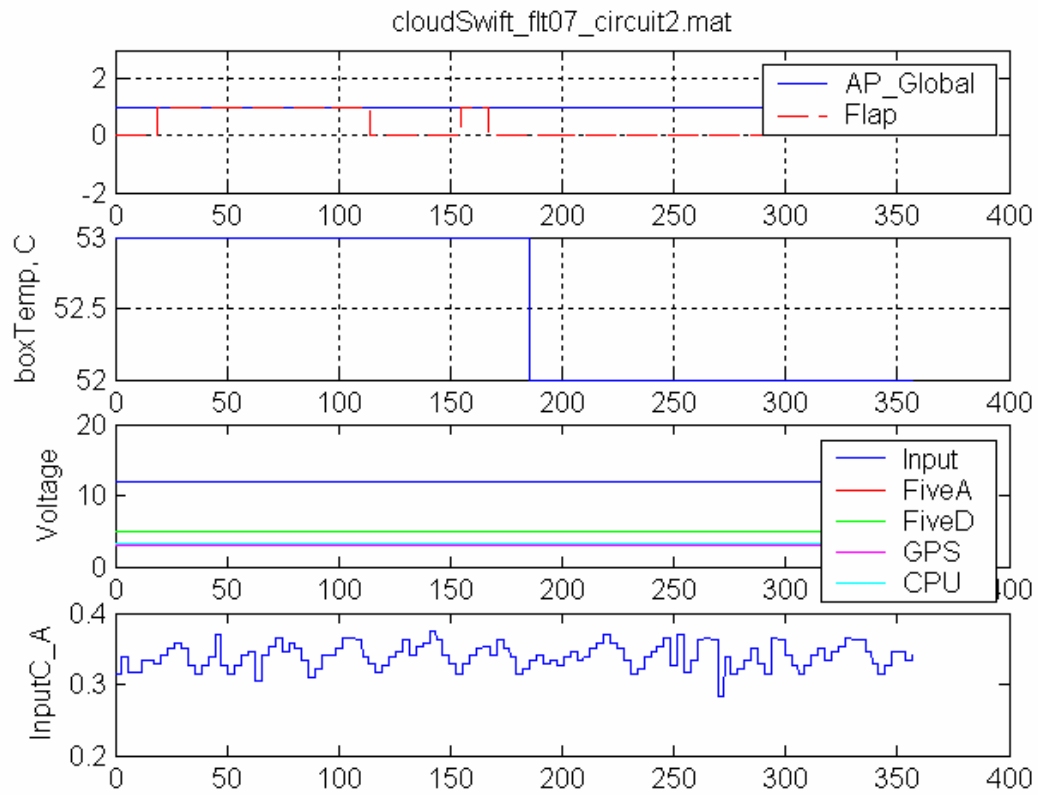
Flight 7, circuit 2

Note altitude loss when soaring is engaged. Mode logic was set for too small vertical velocity.

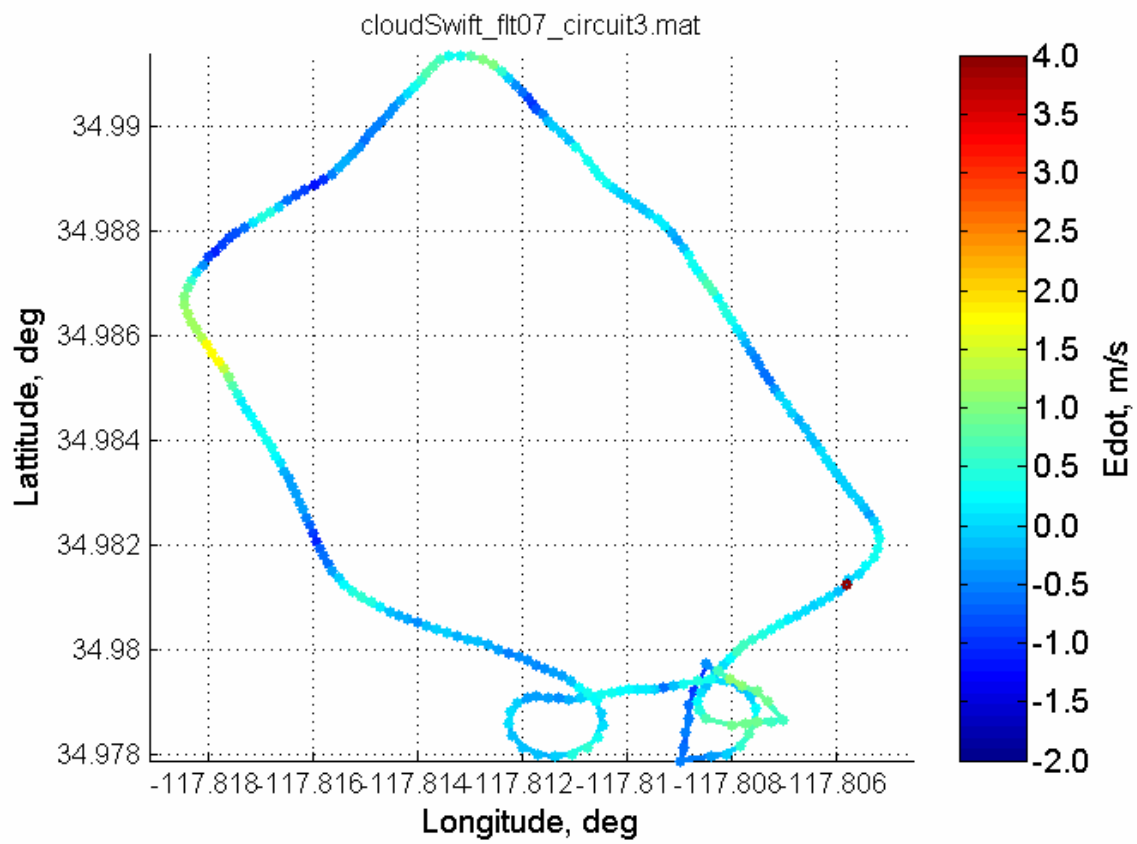


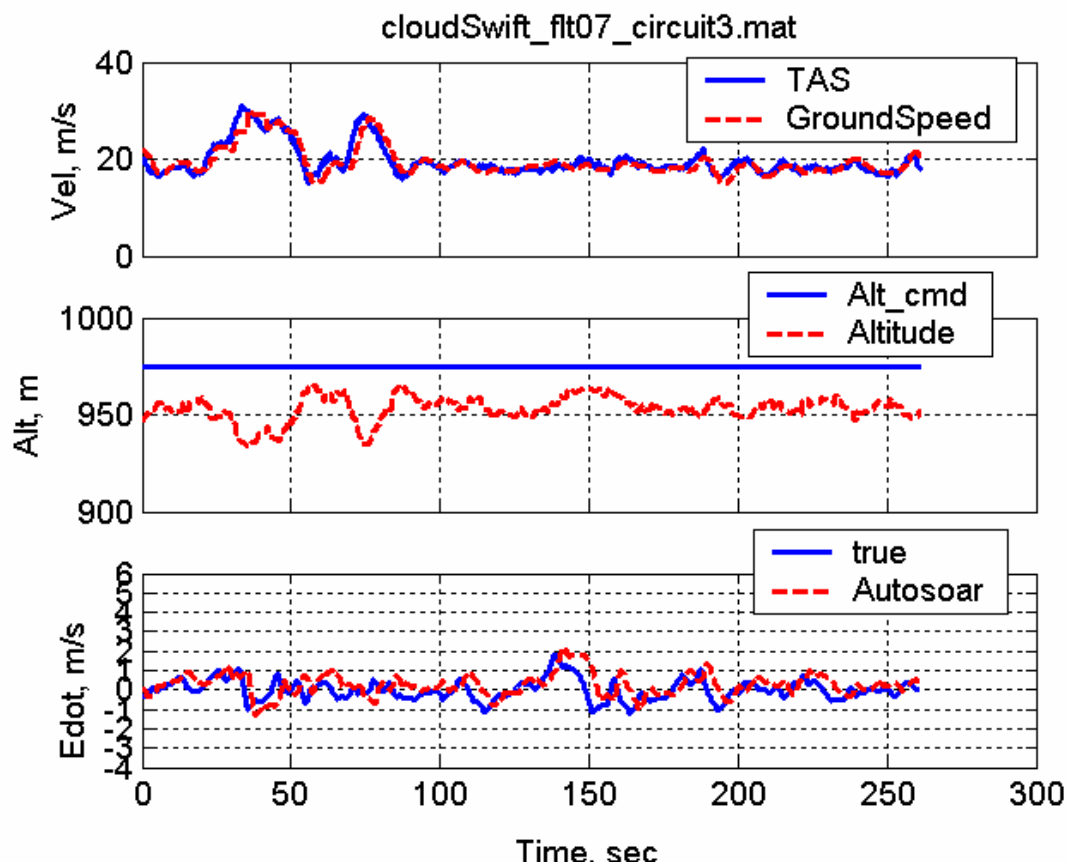
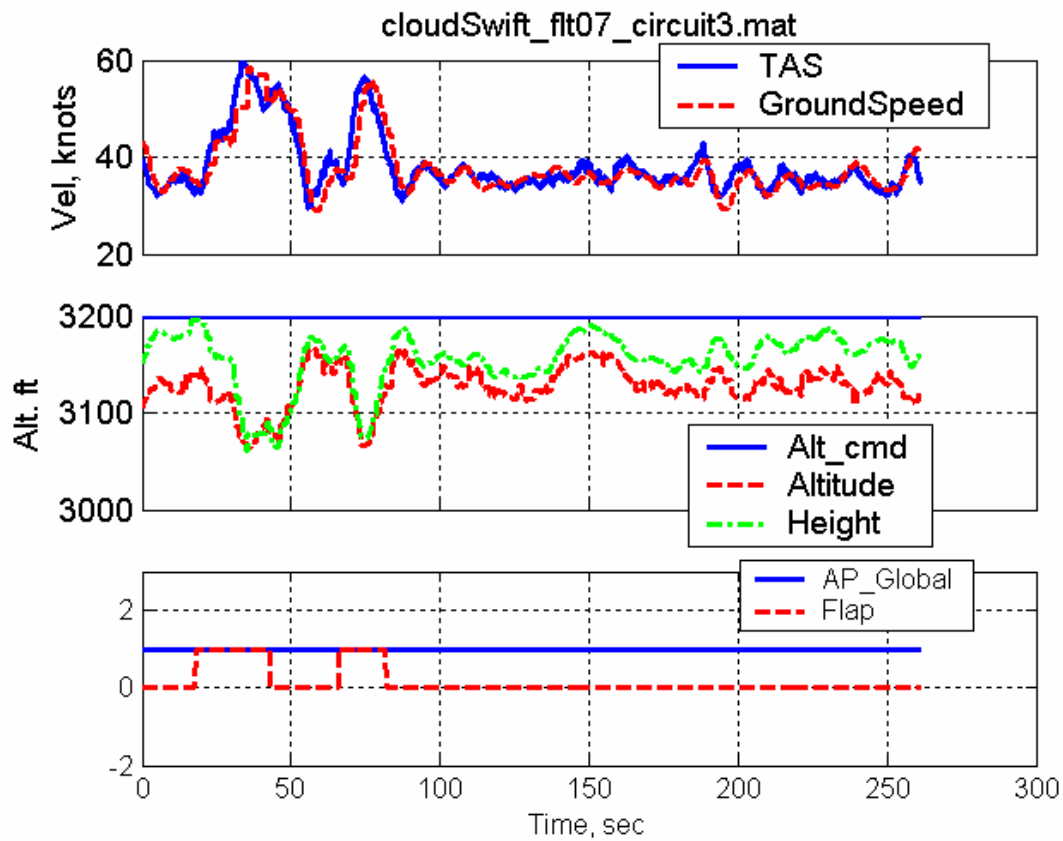


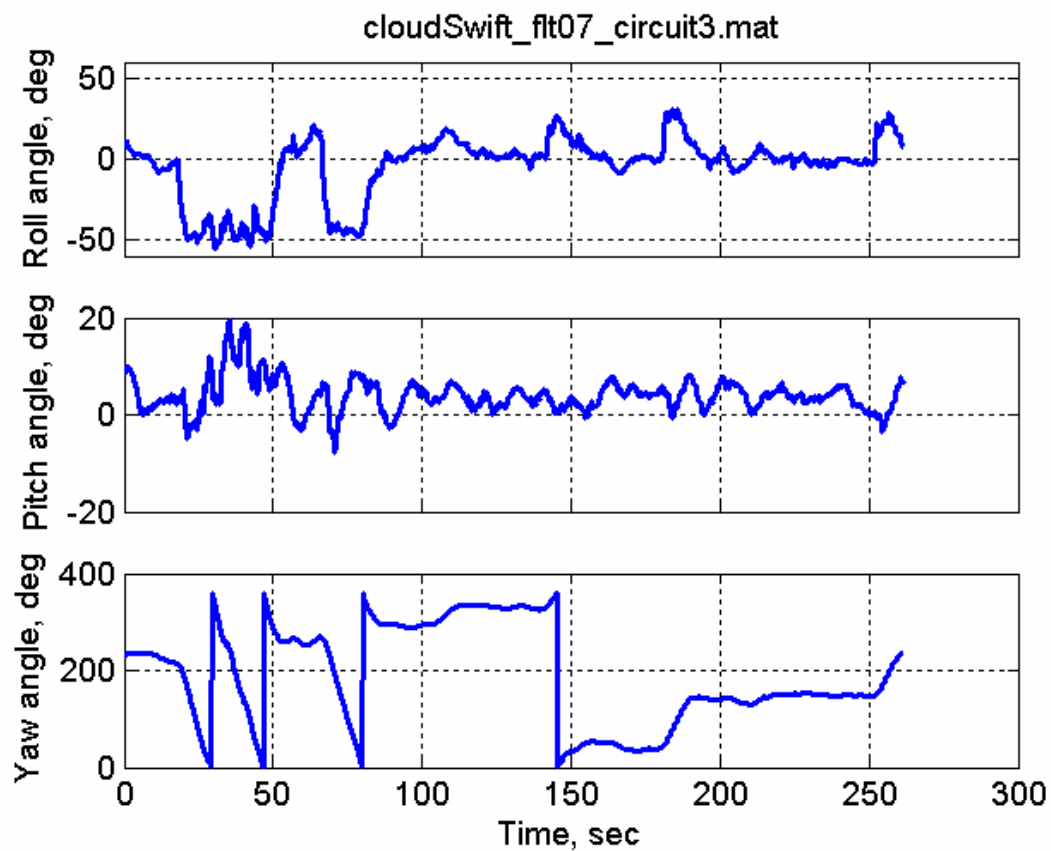
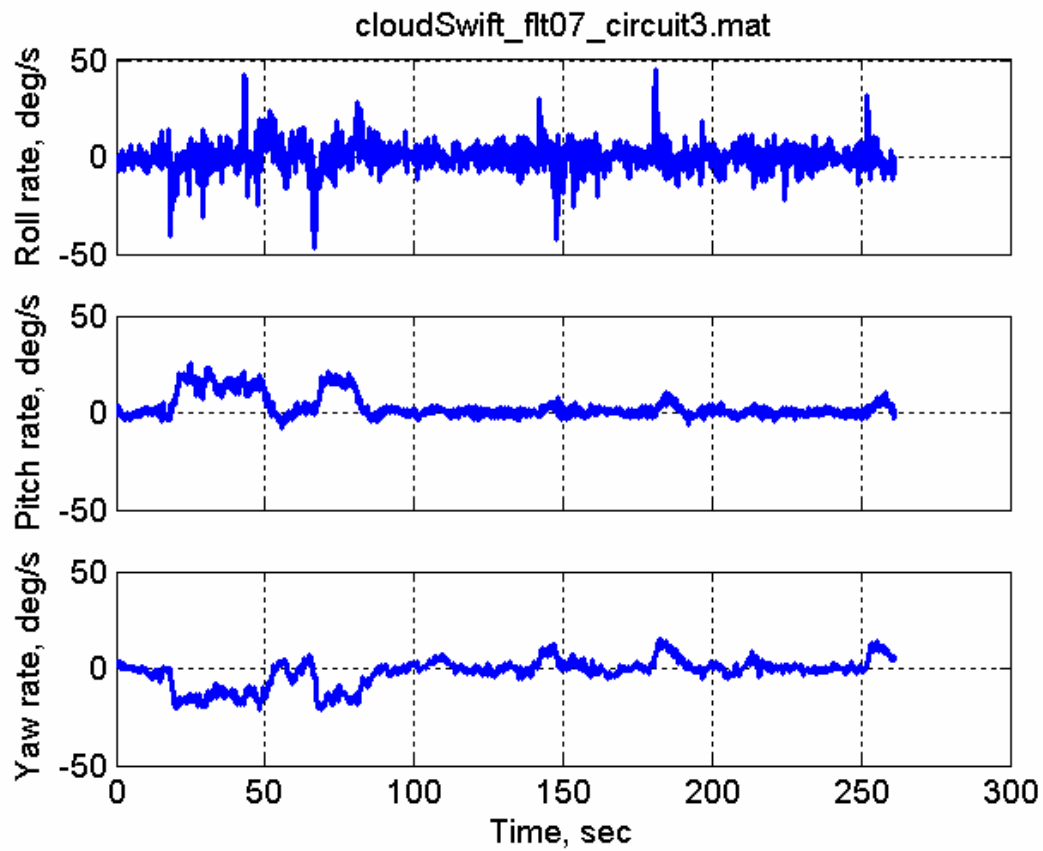


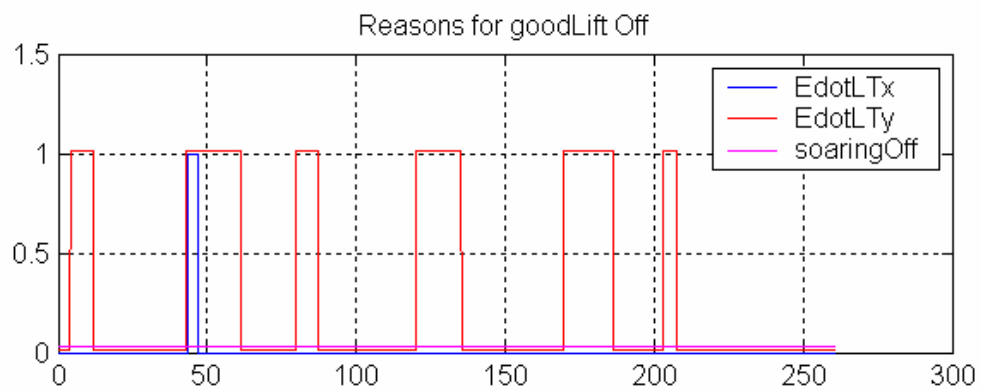
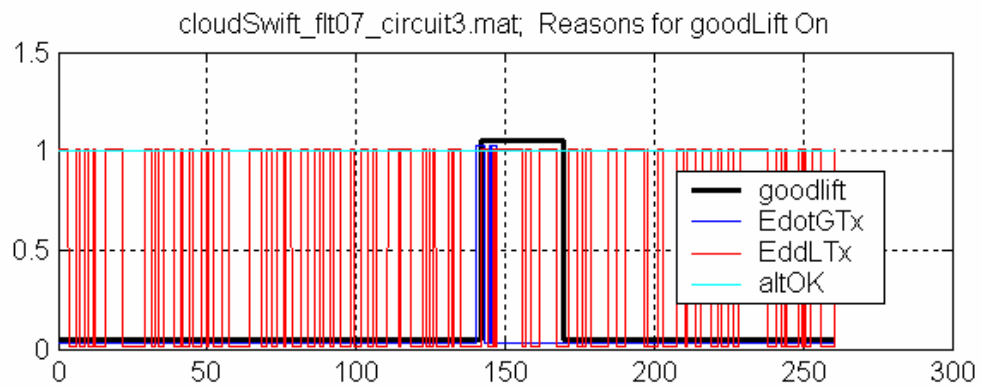
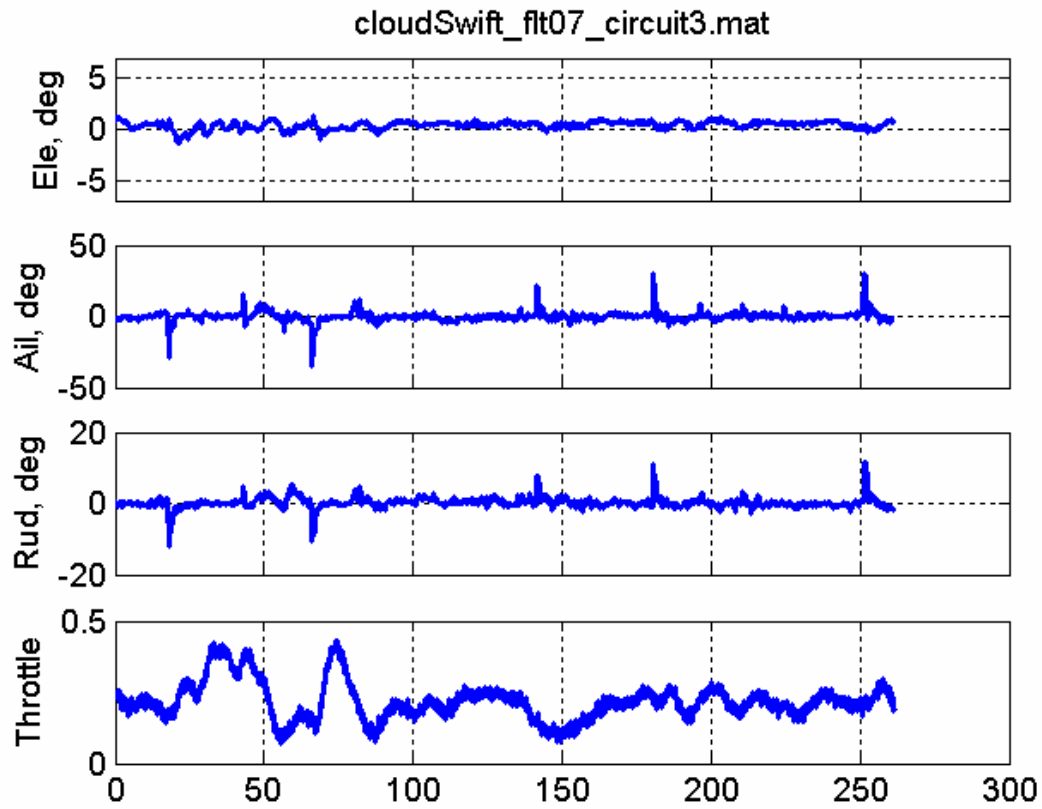


Flight 7, circuit 3



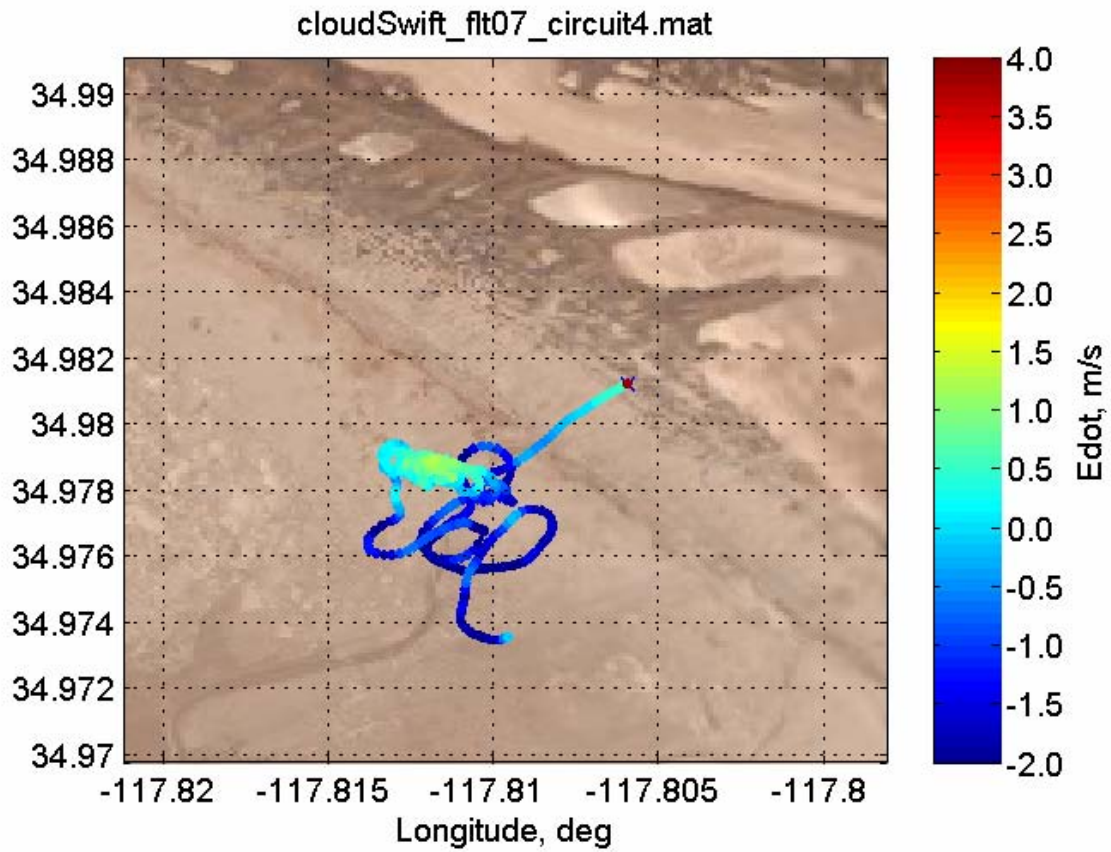


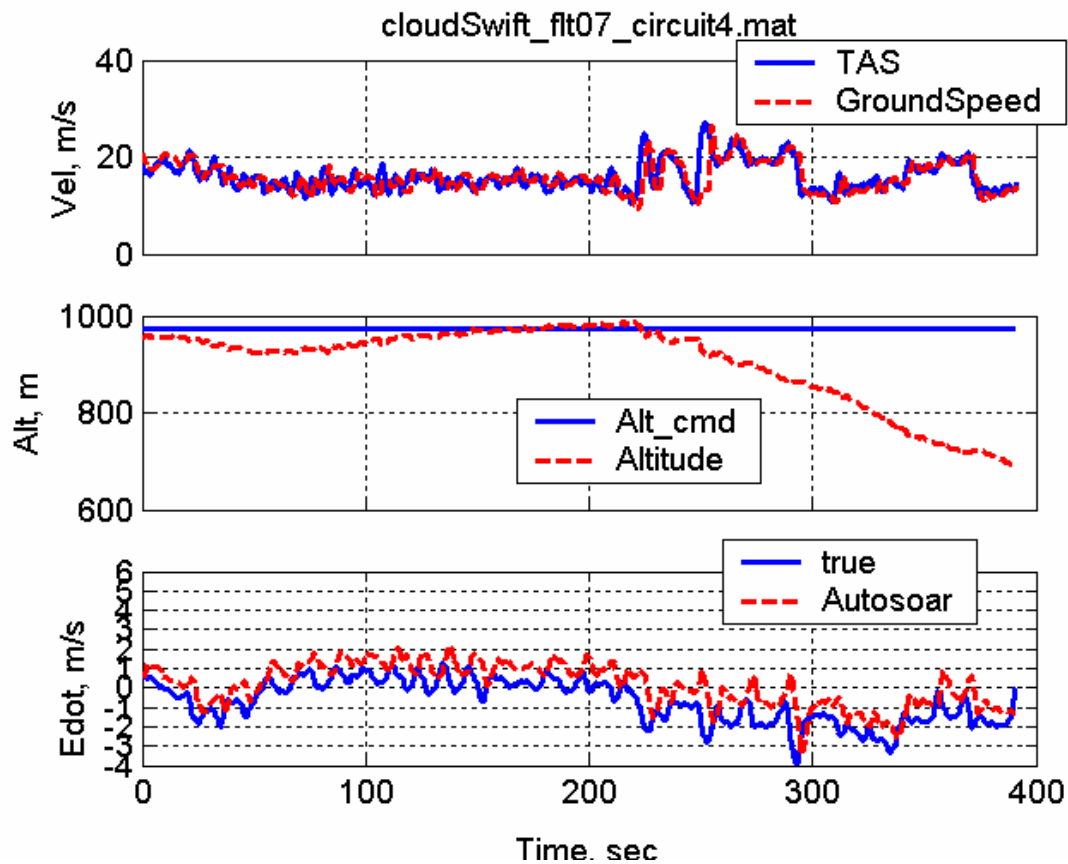
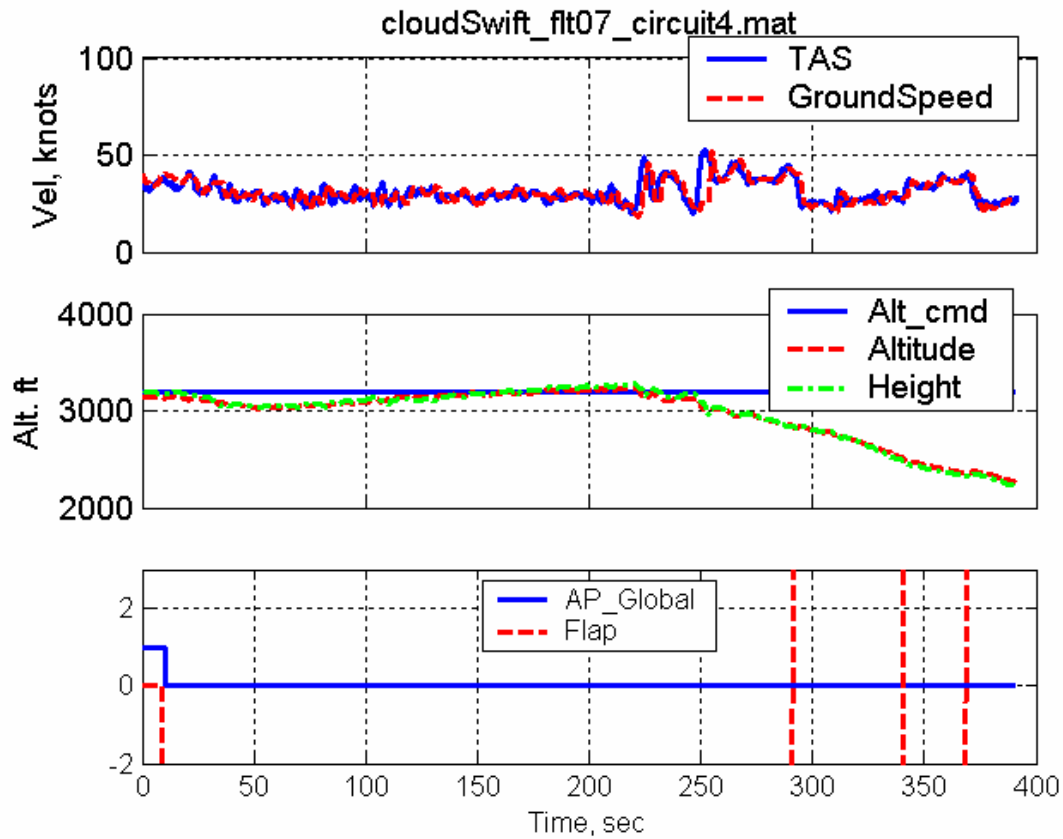


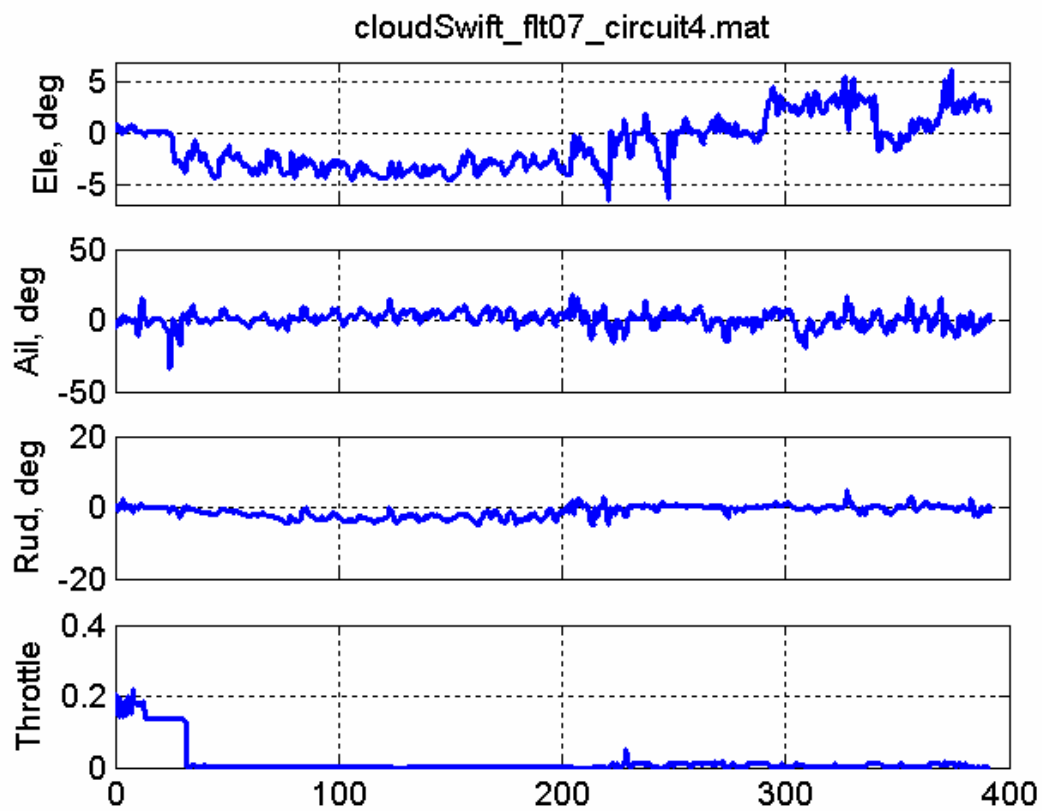
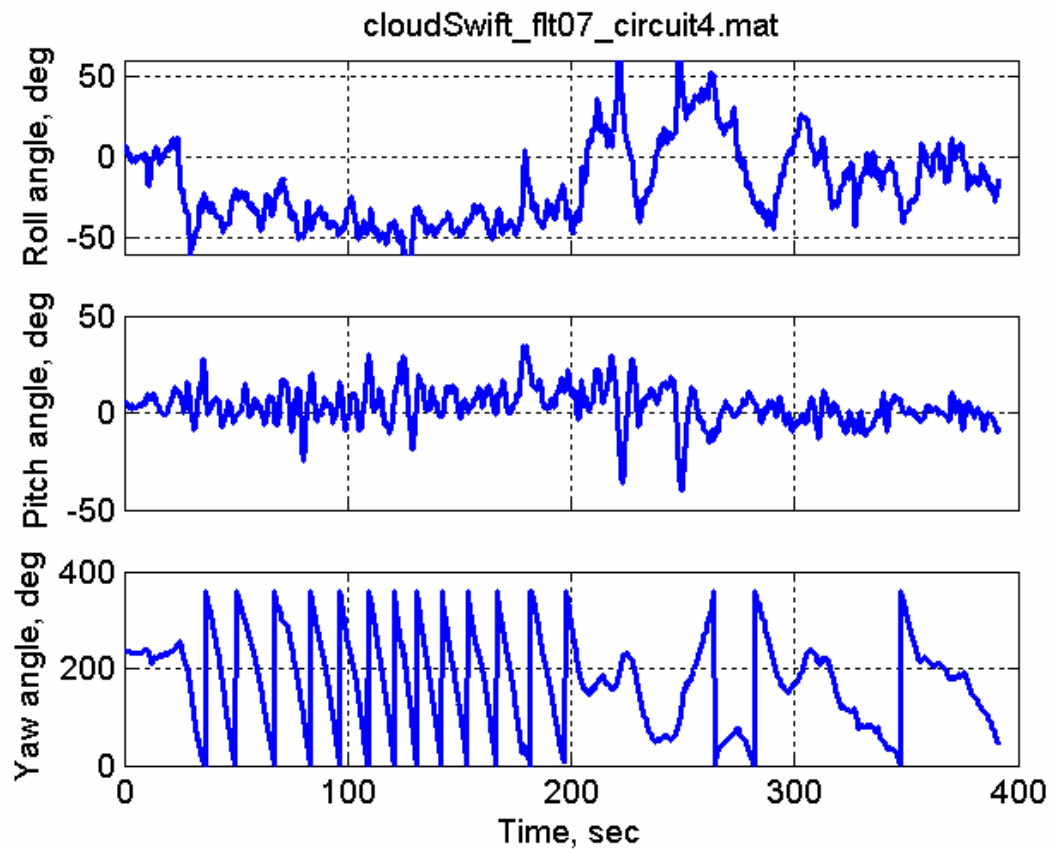


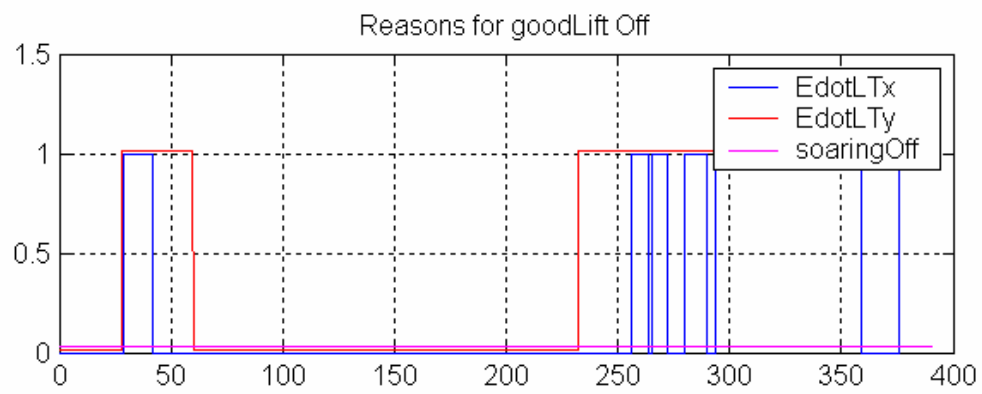
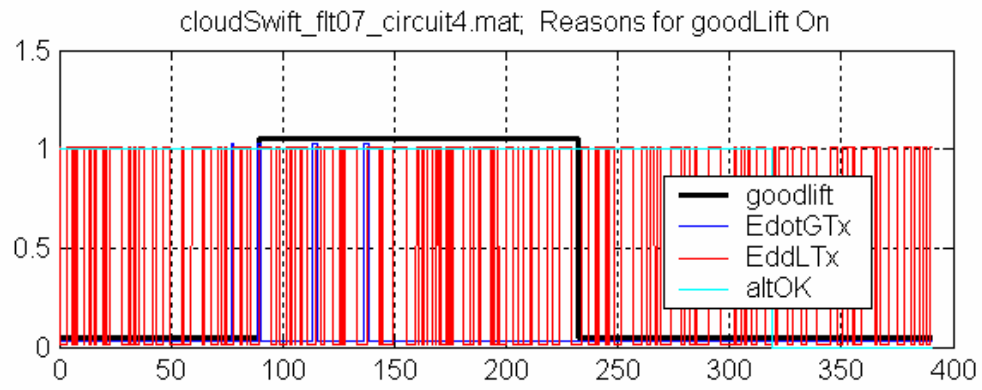
Flight 7, circuit 4

Piloted soaring in weak lift.



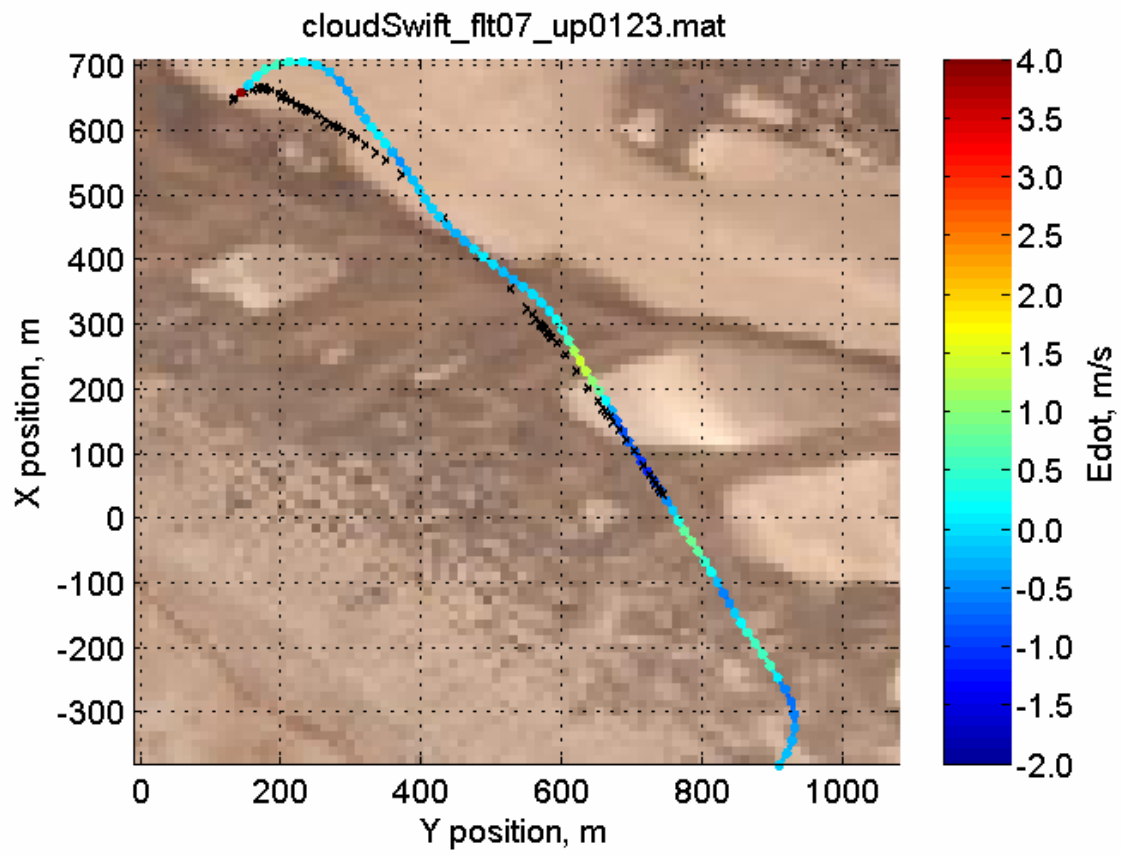


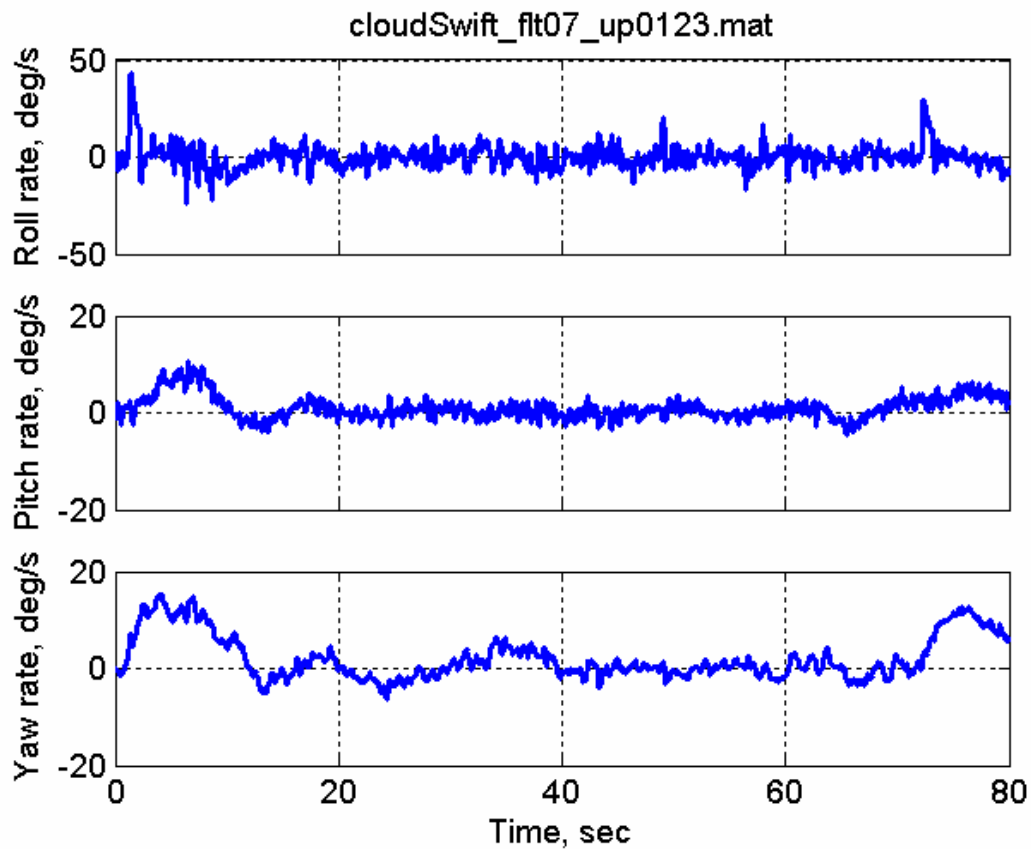
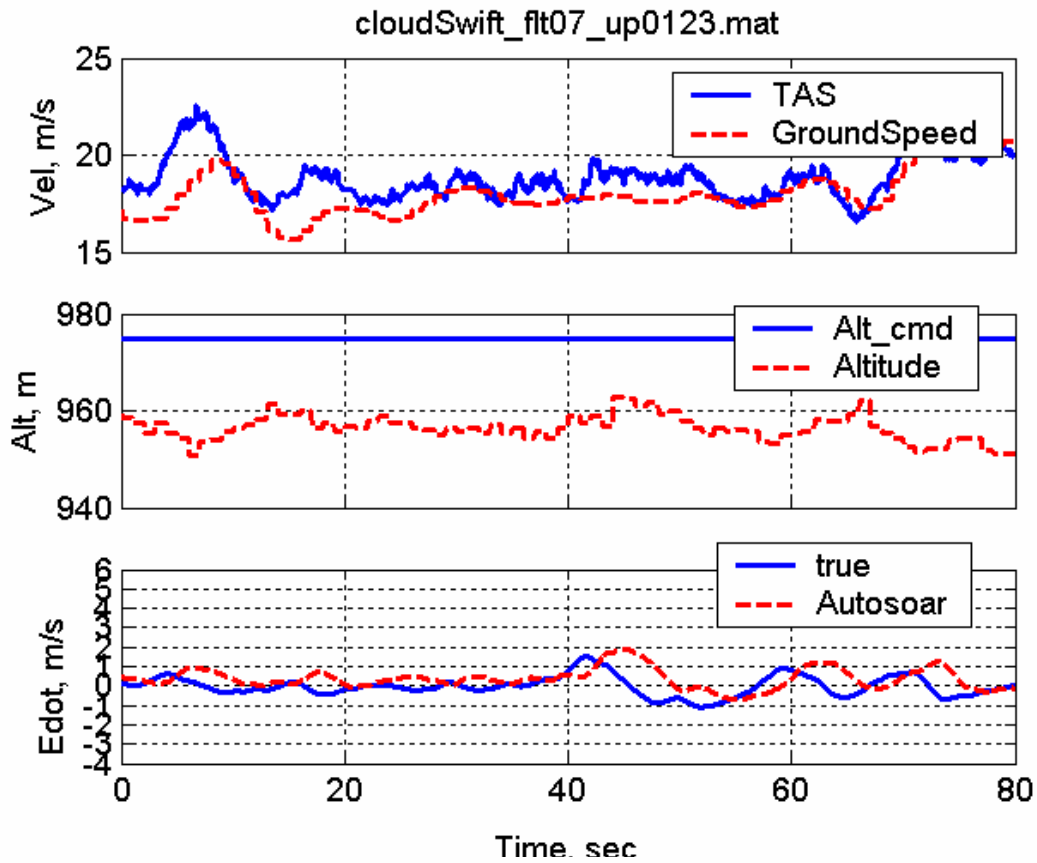


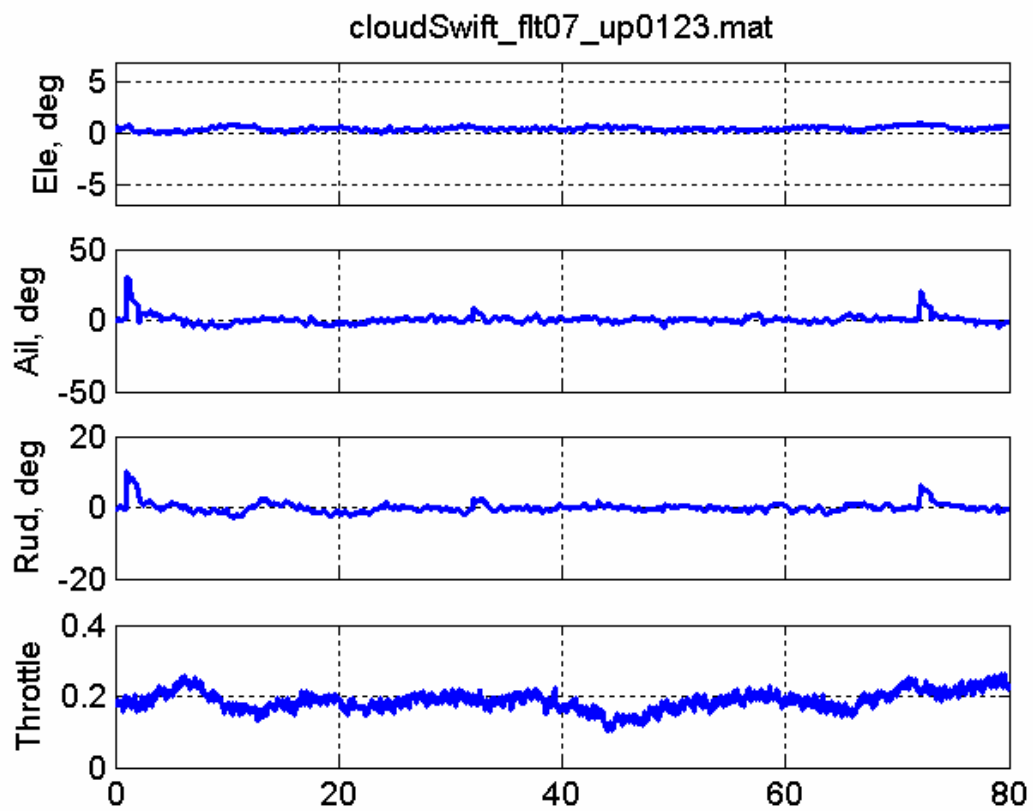
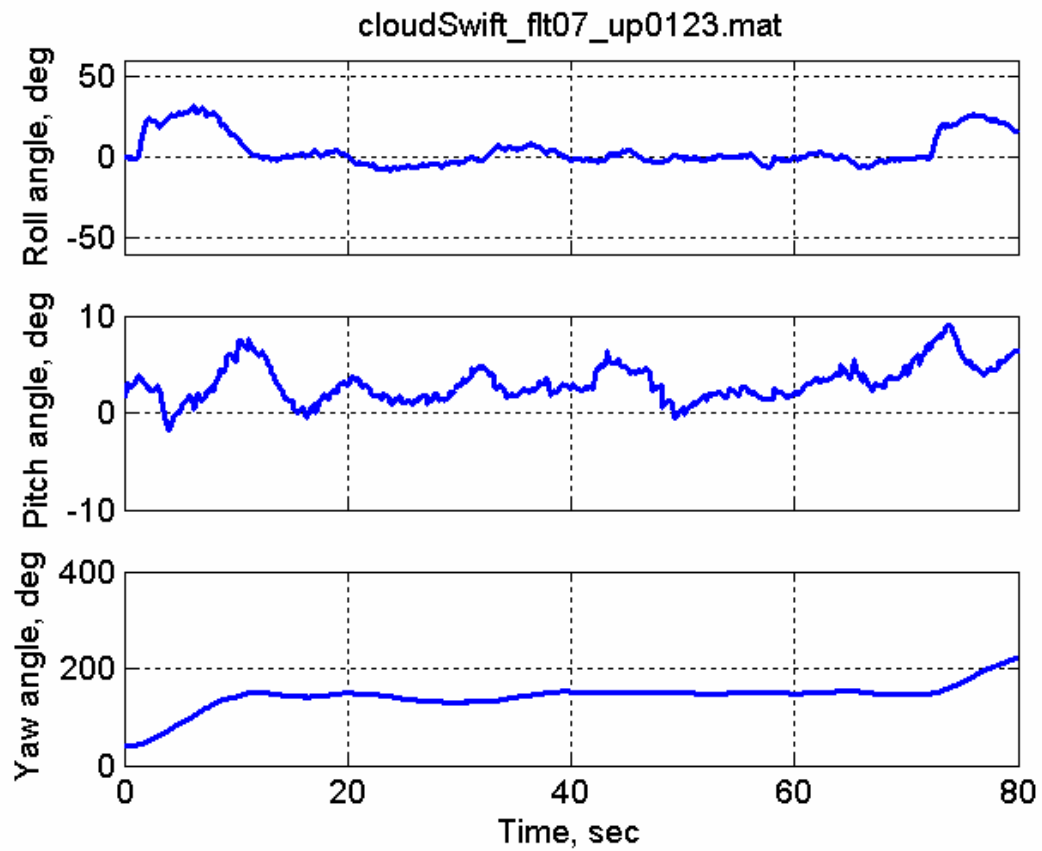


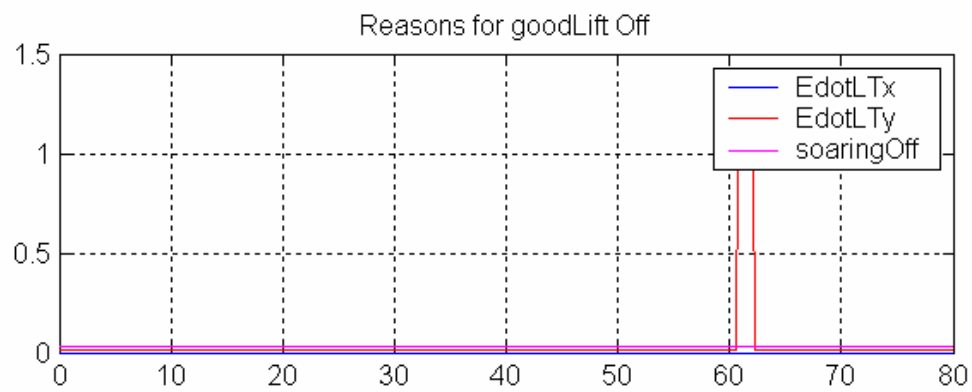
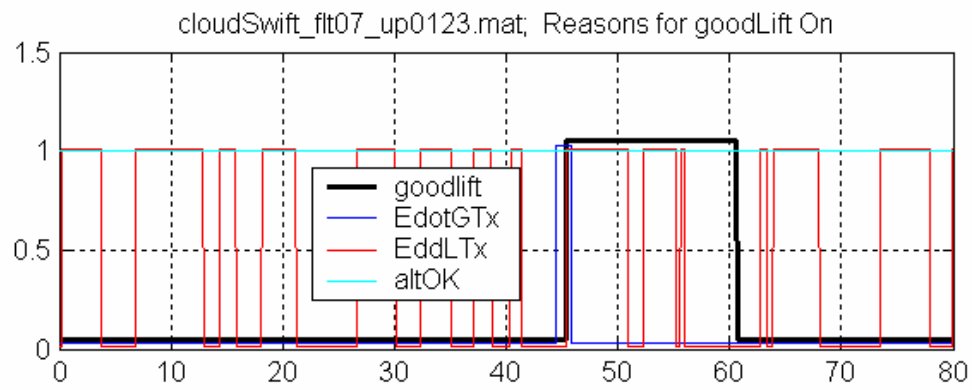
Flight 7, updrafts 1-3

Straight flight through three small thermals.

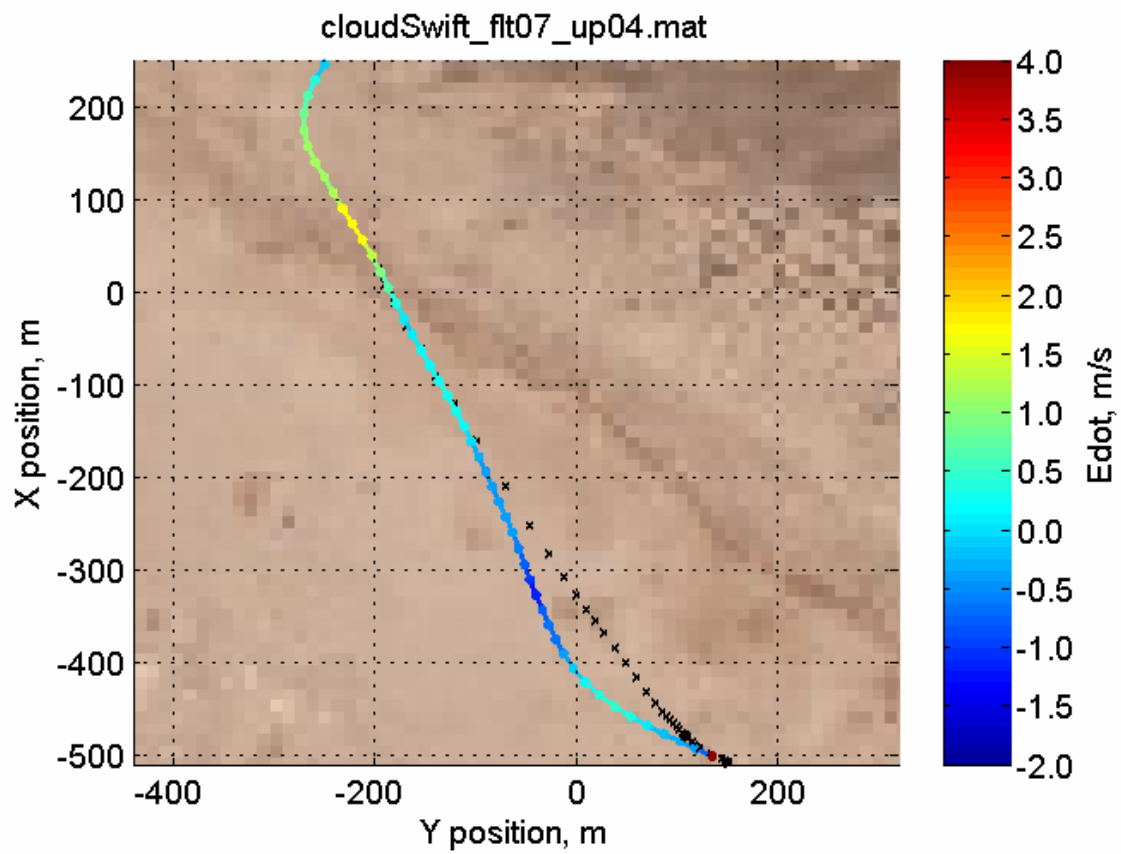


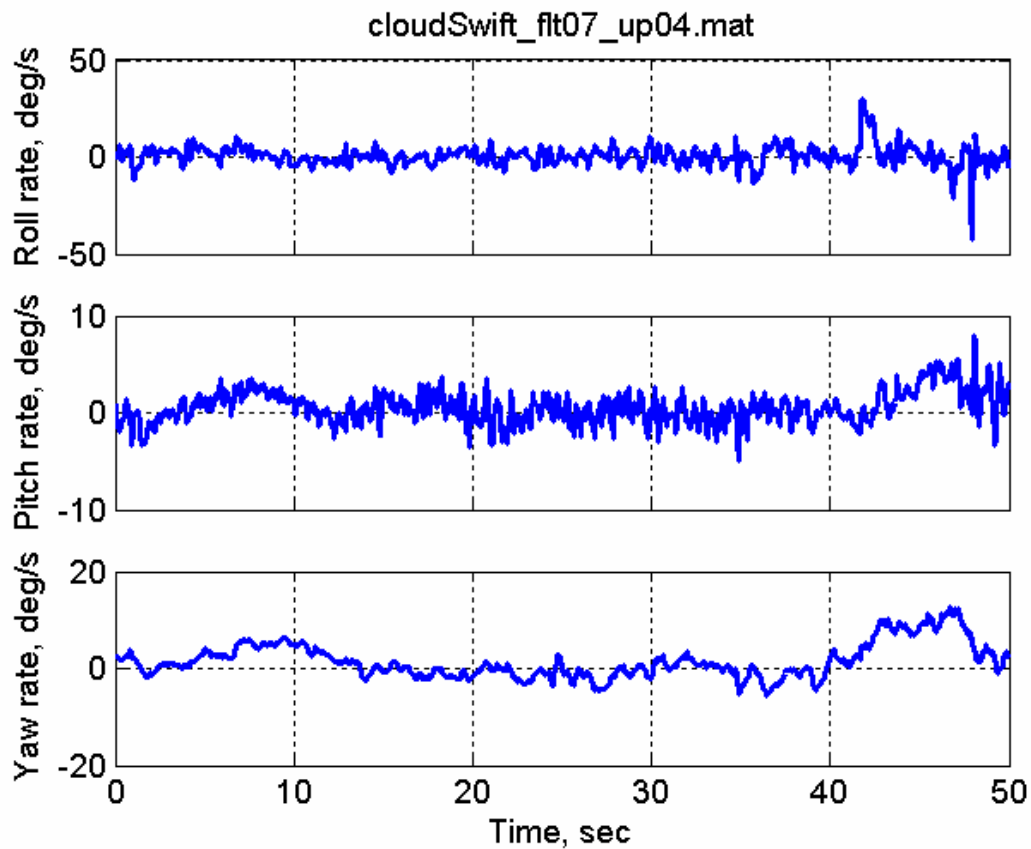
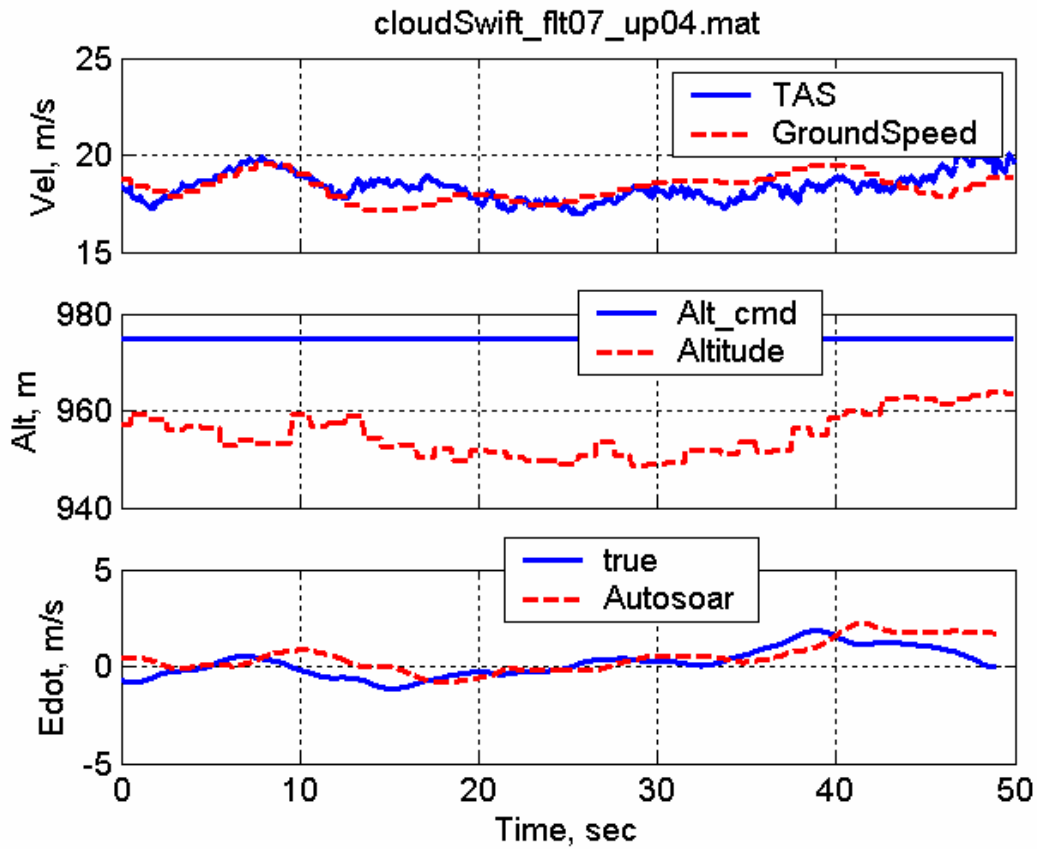


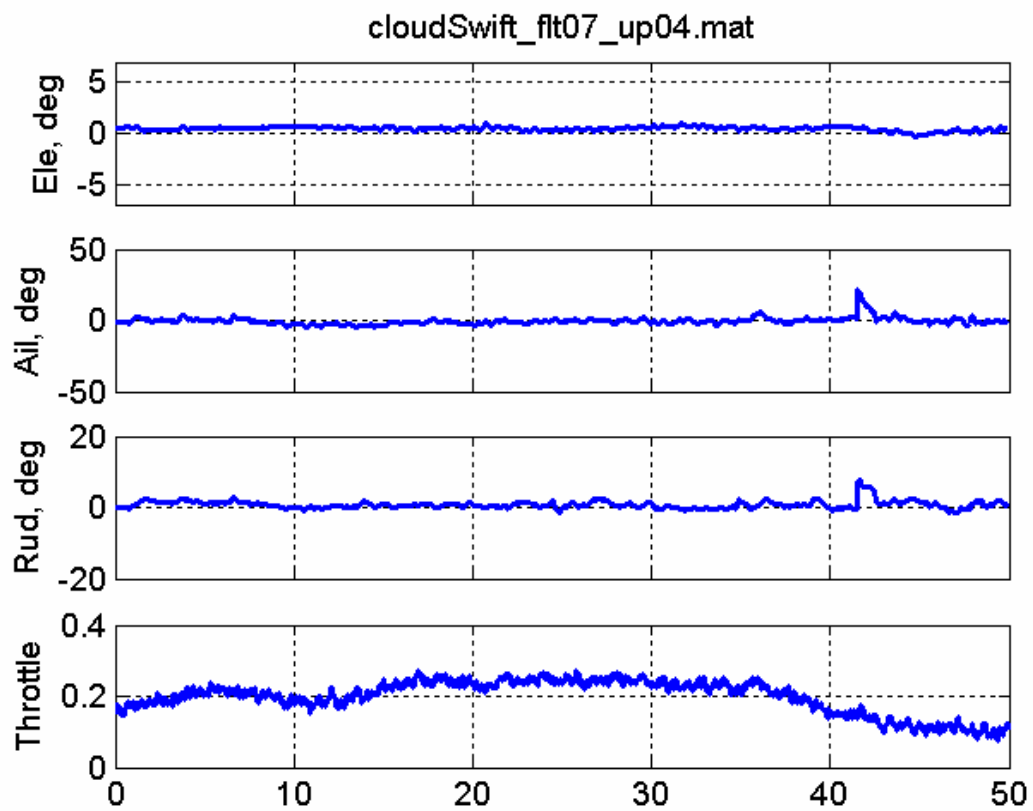
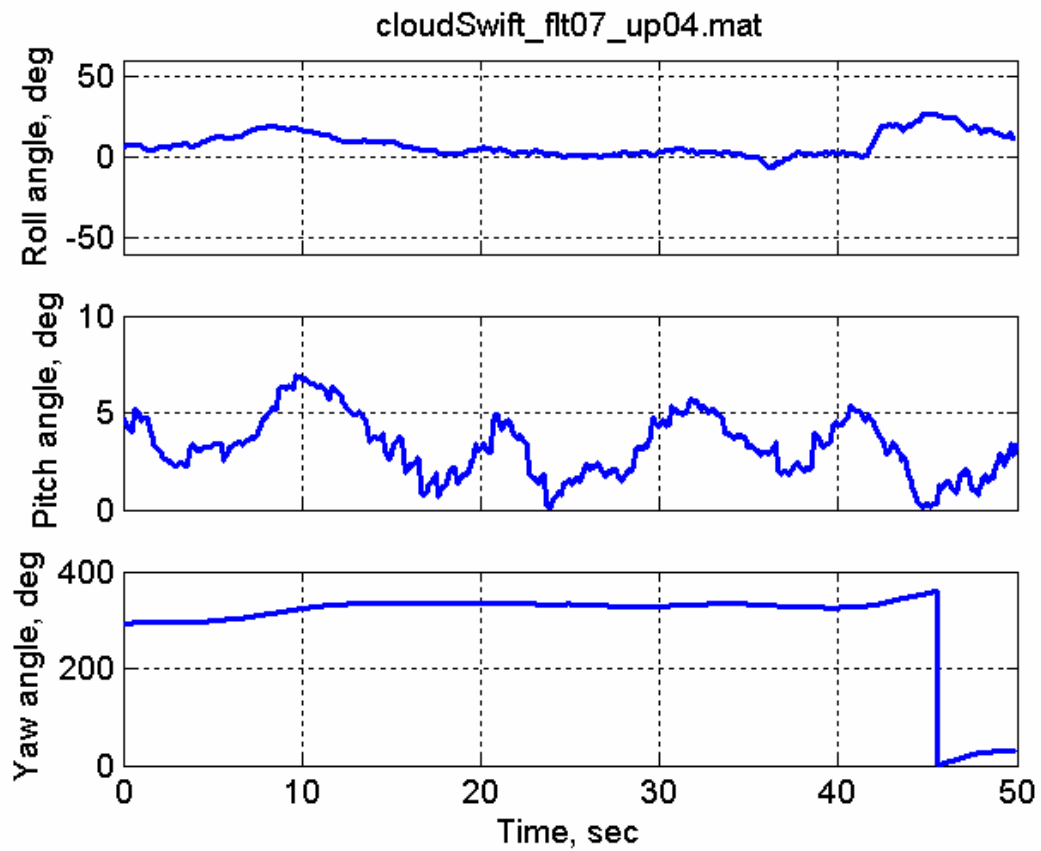


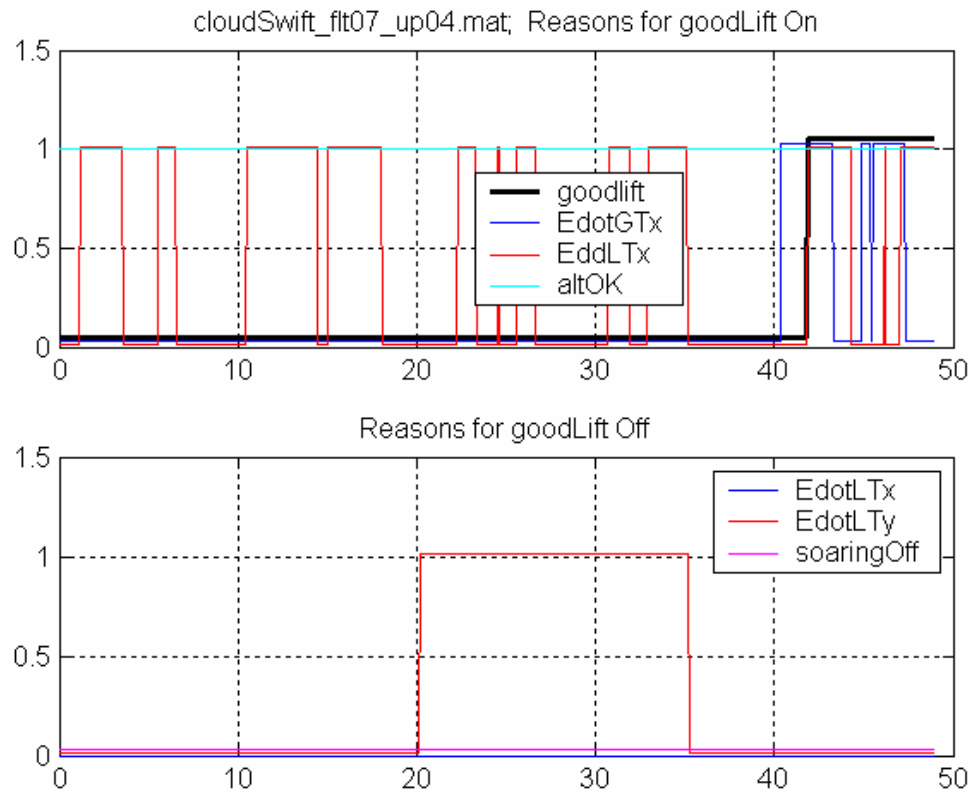


Flight 7, updraft 4



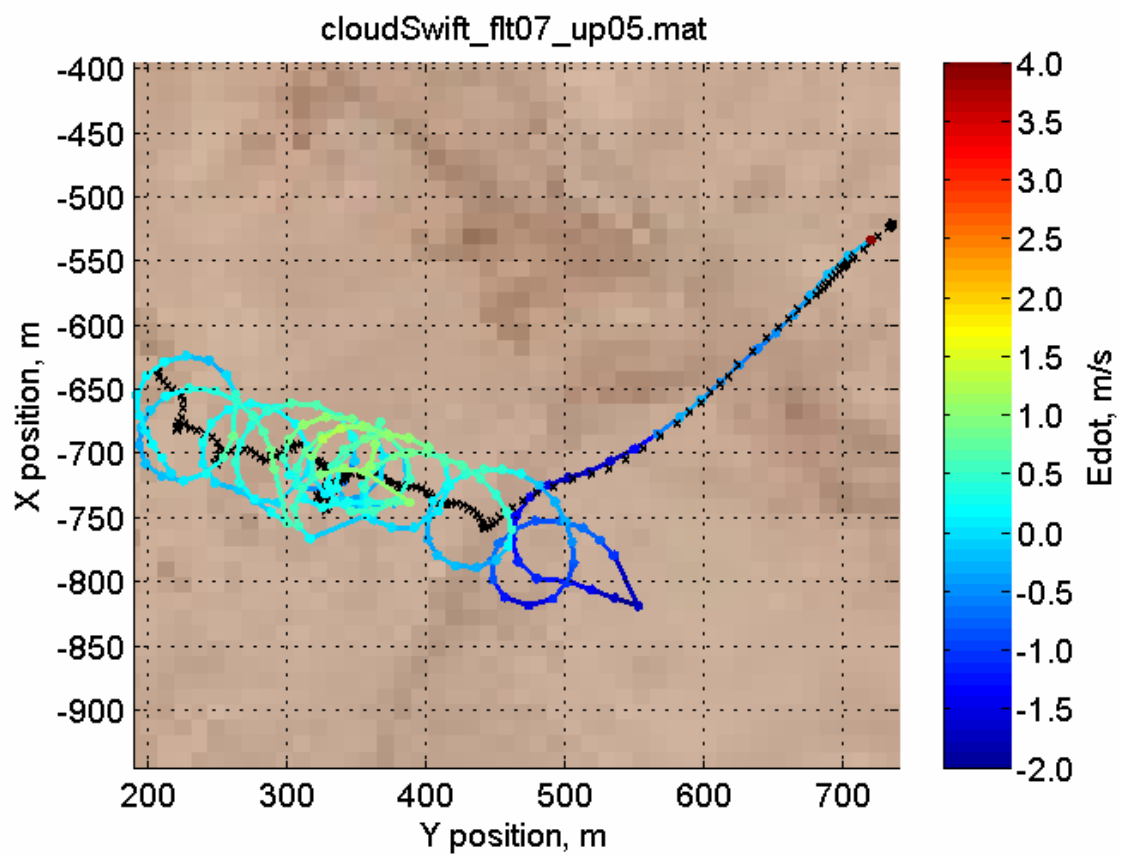


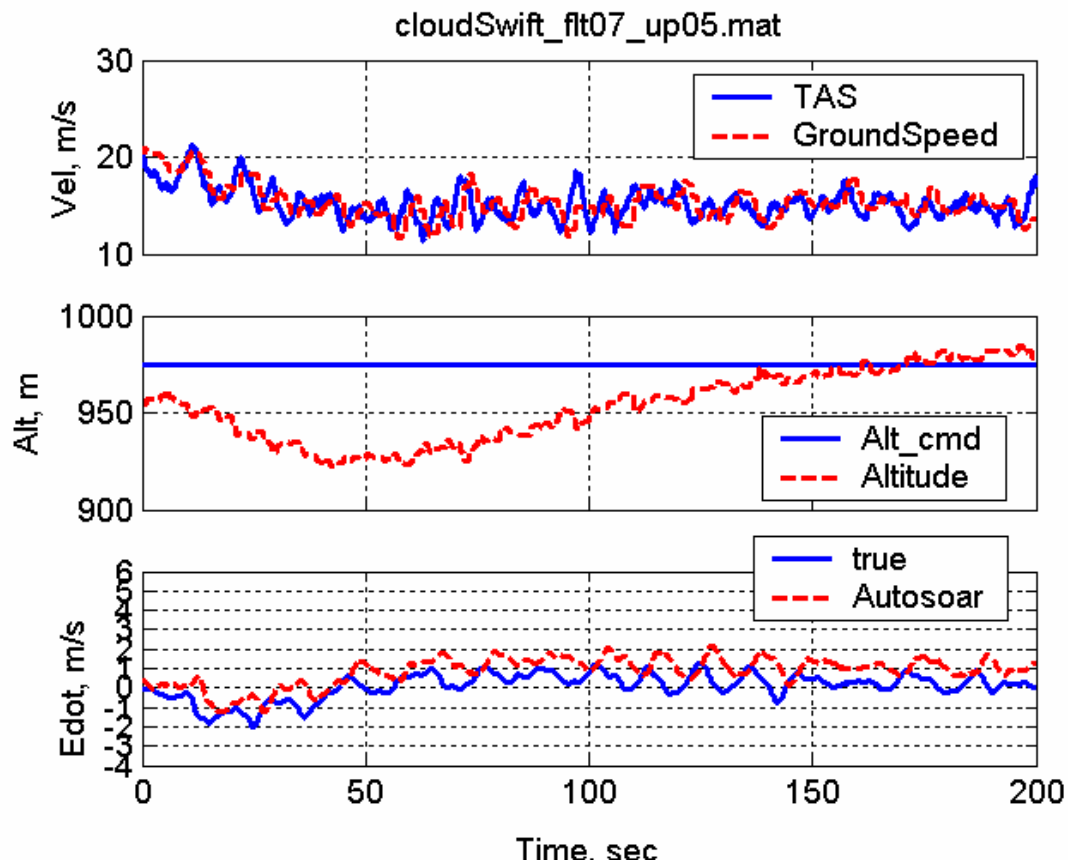
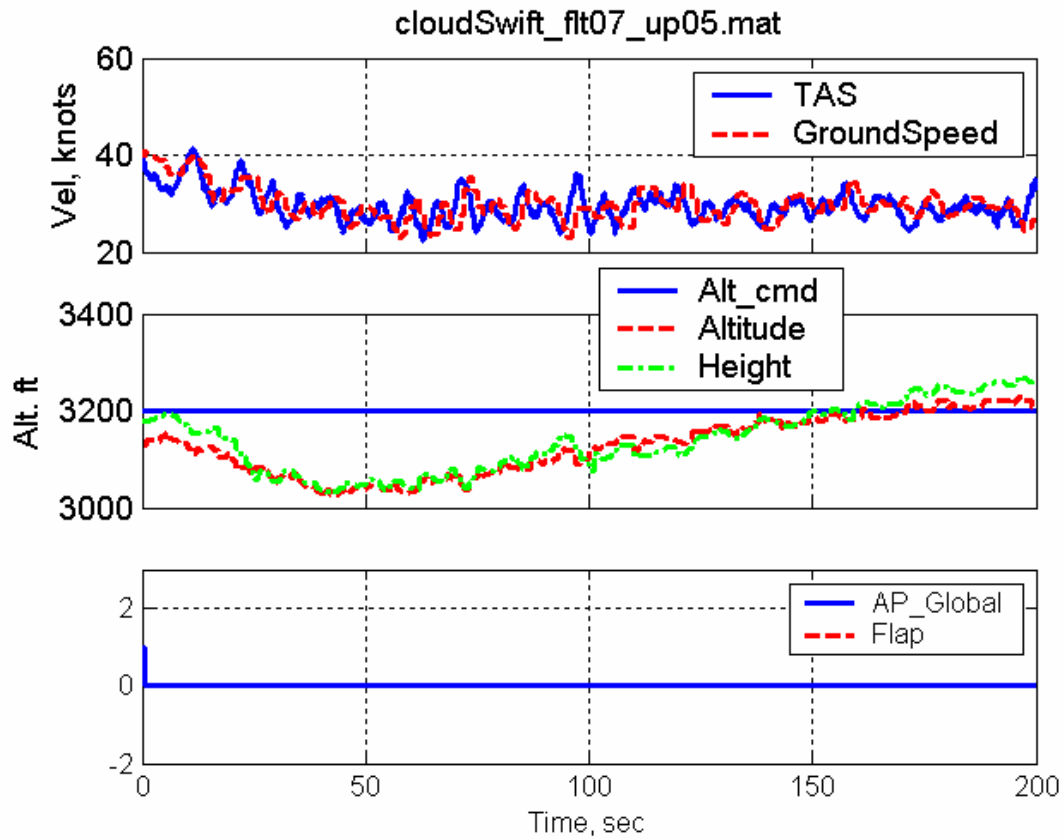


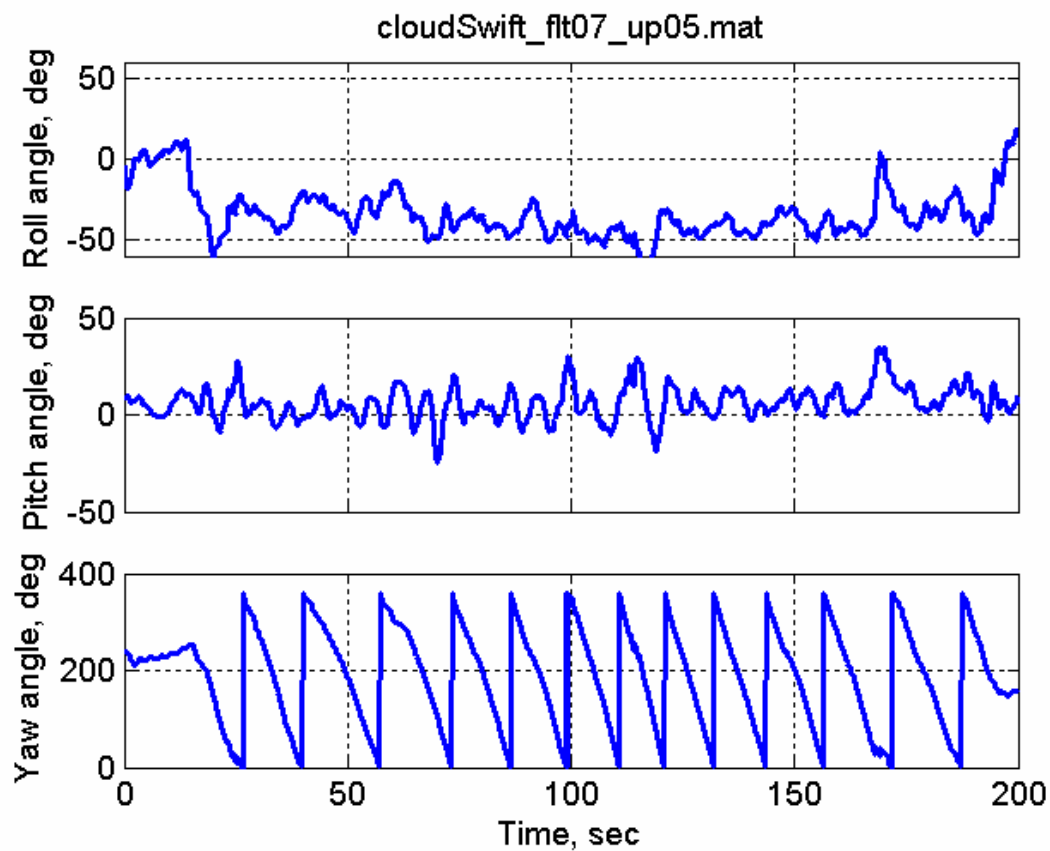
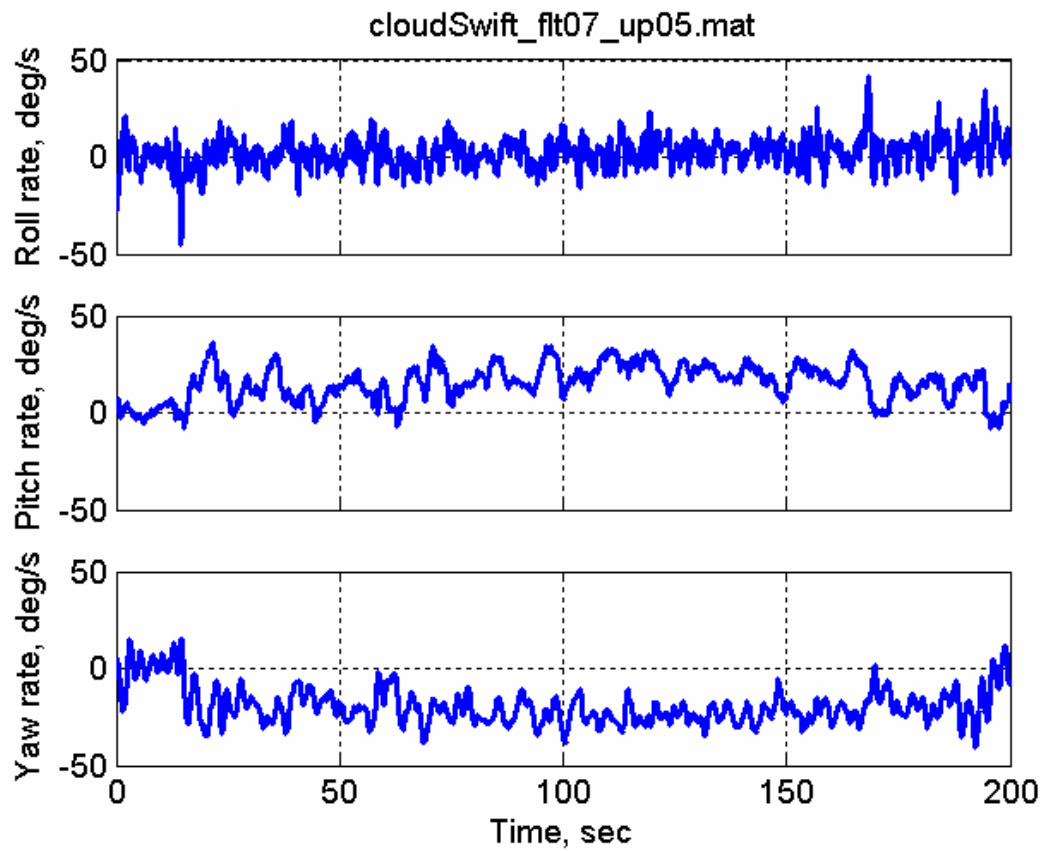


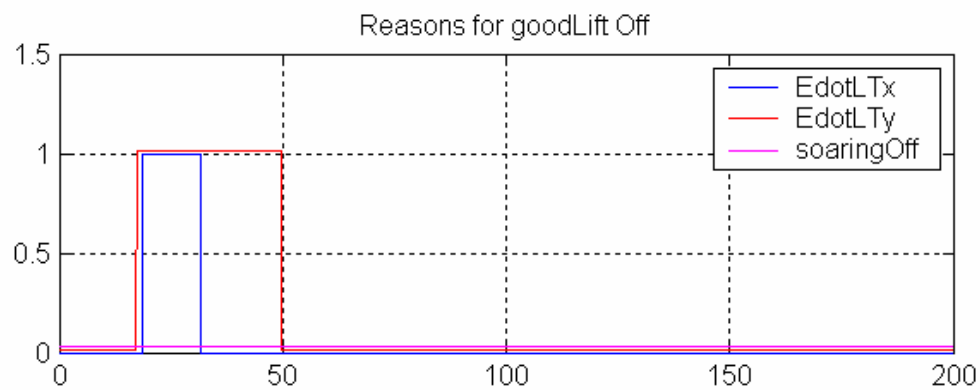
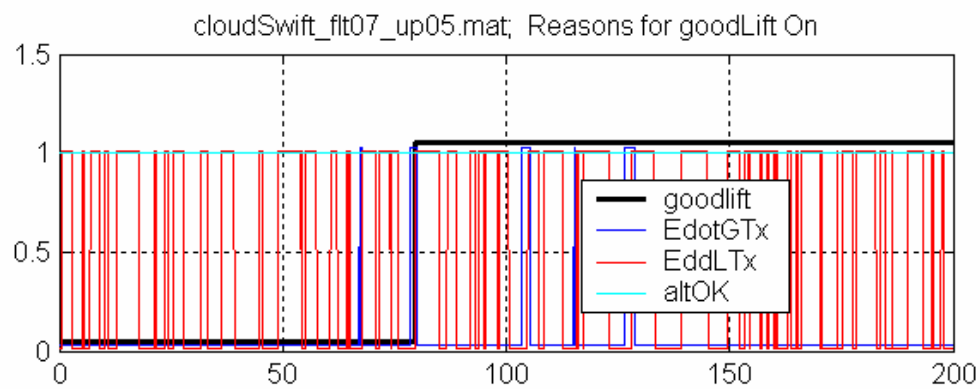
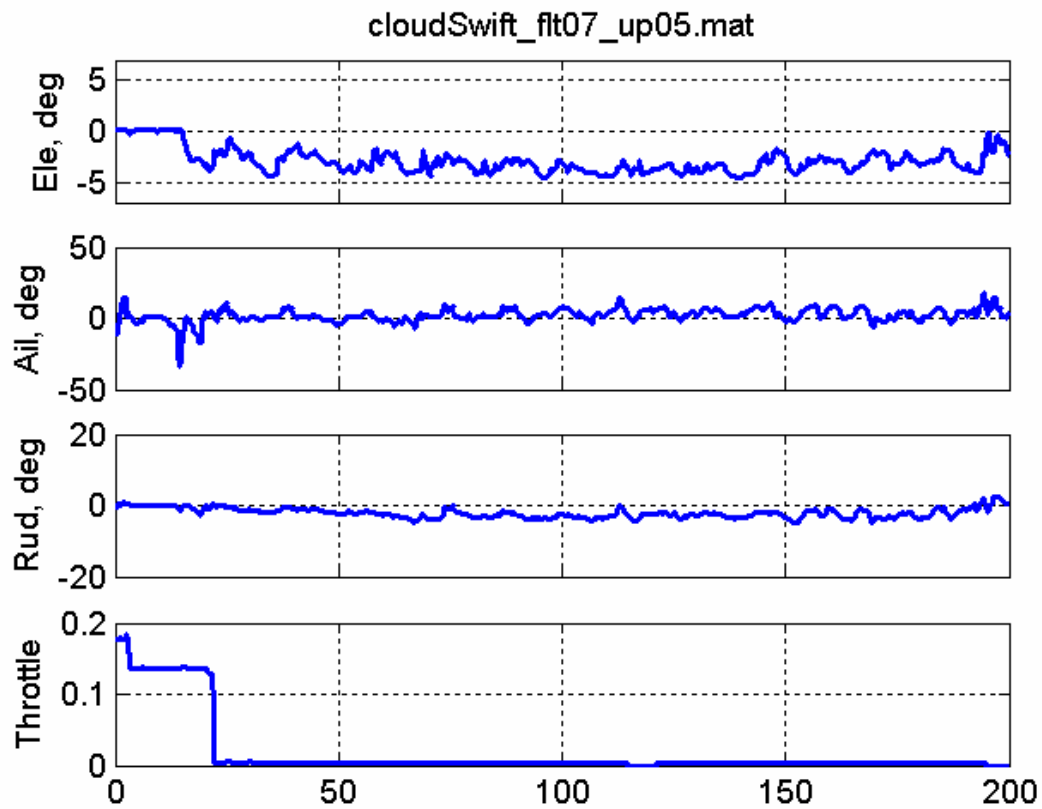
Flight 7, updraft 5

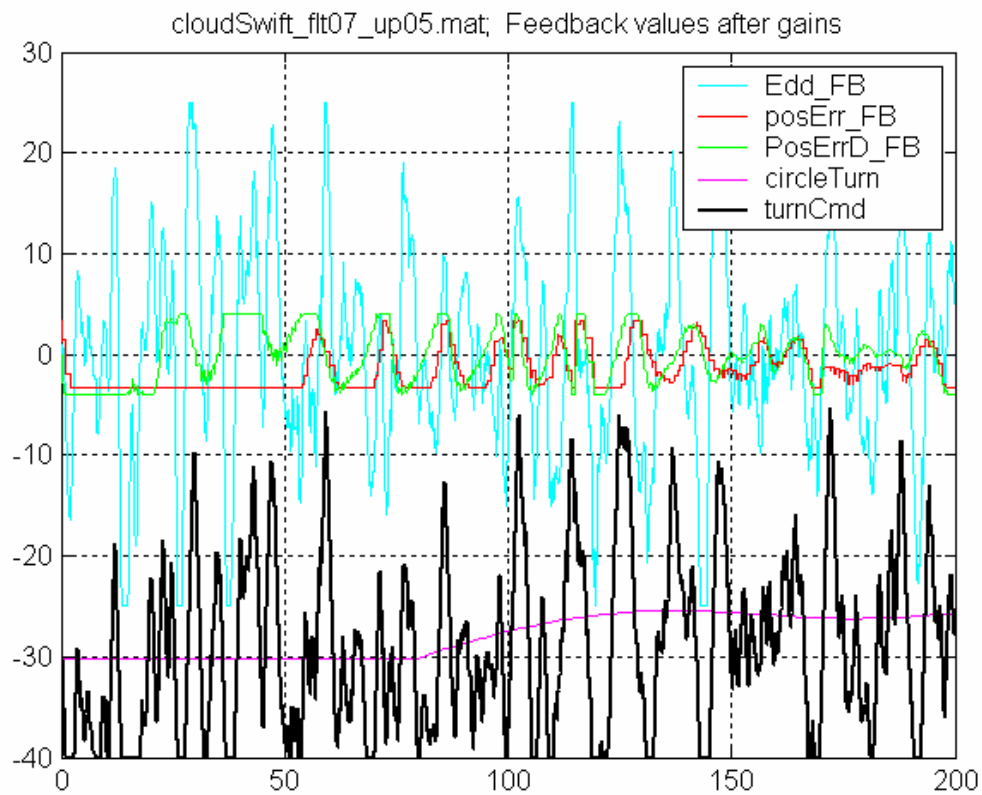
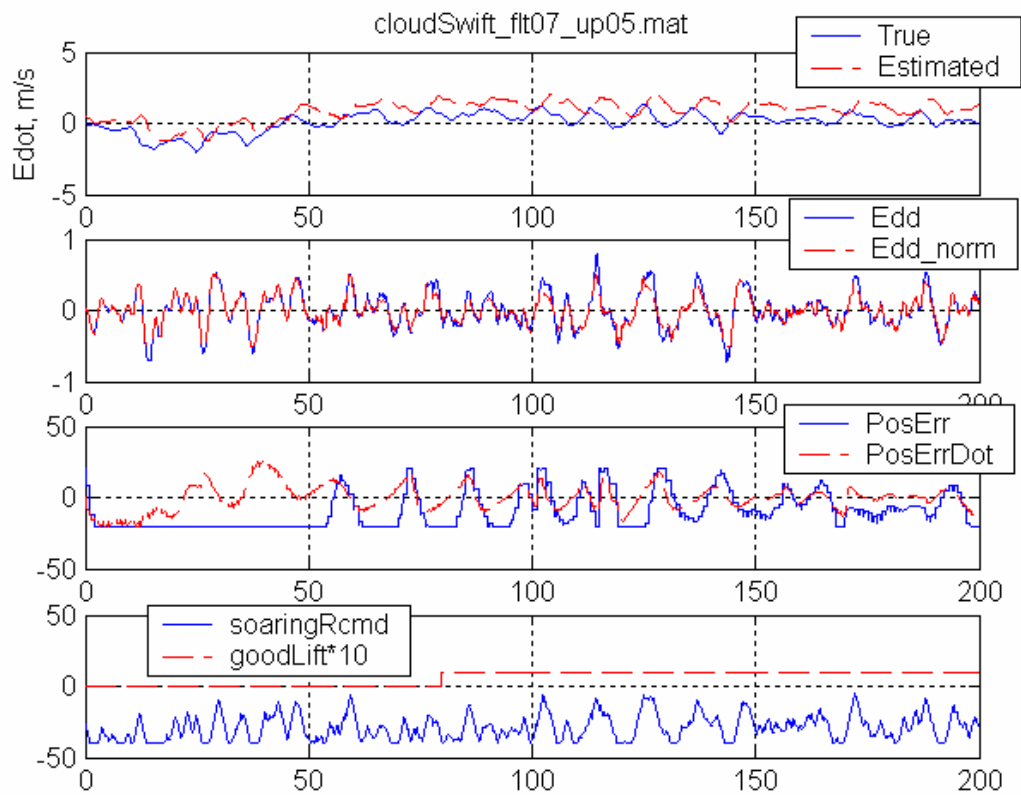
Piloted soaring.





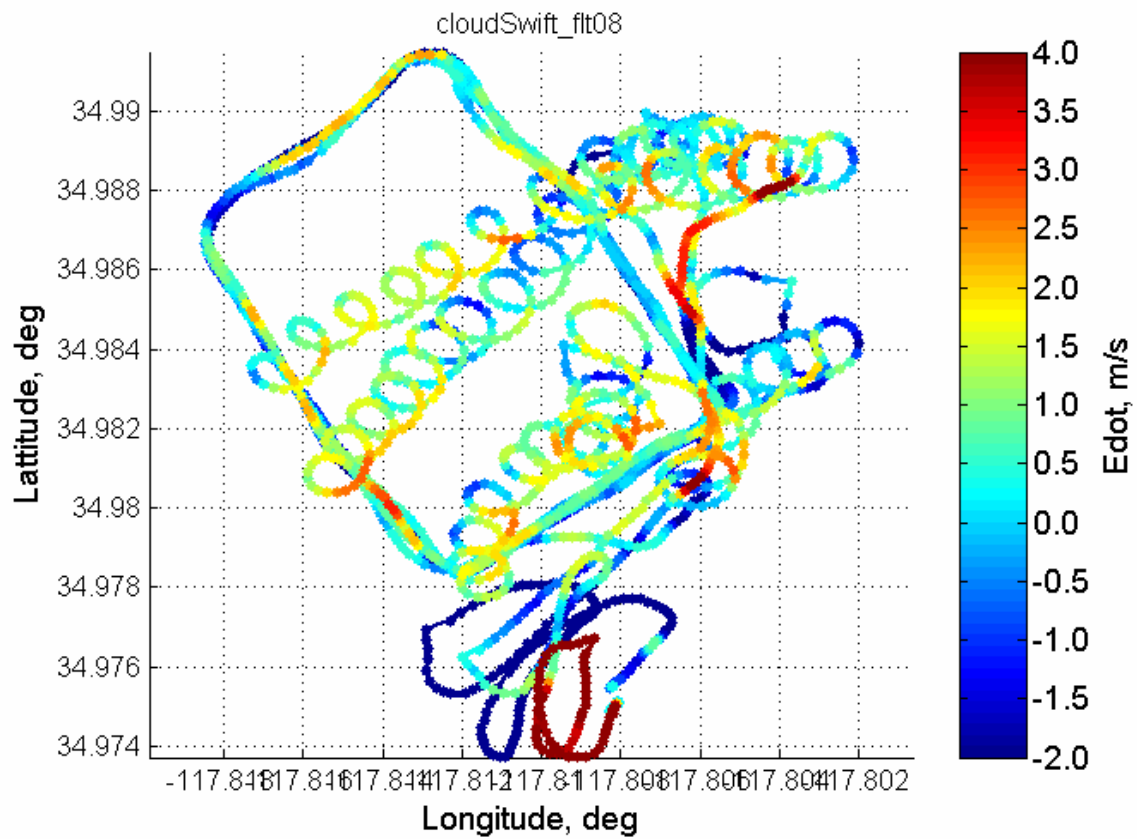


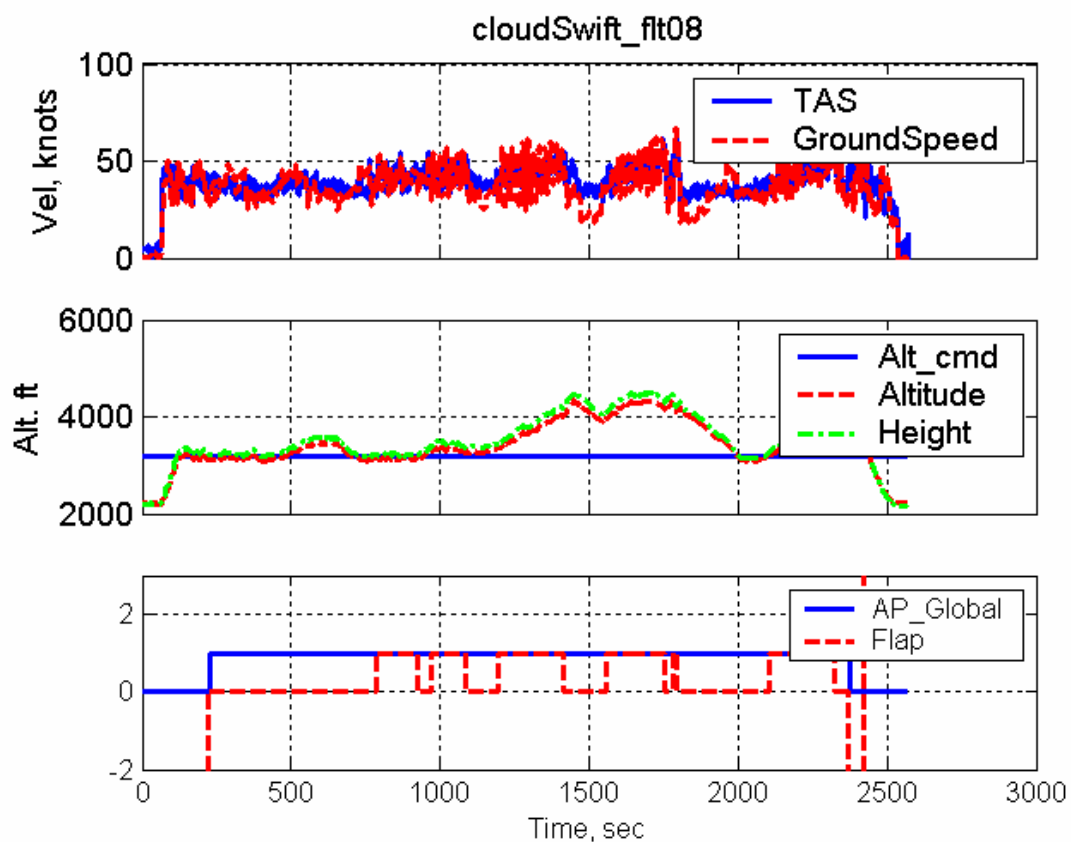
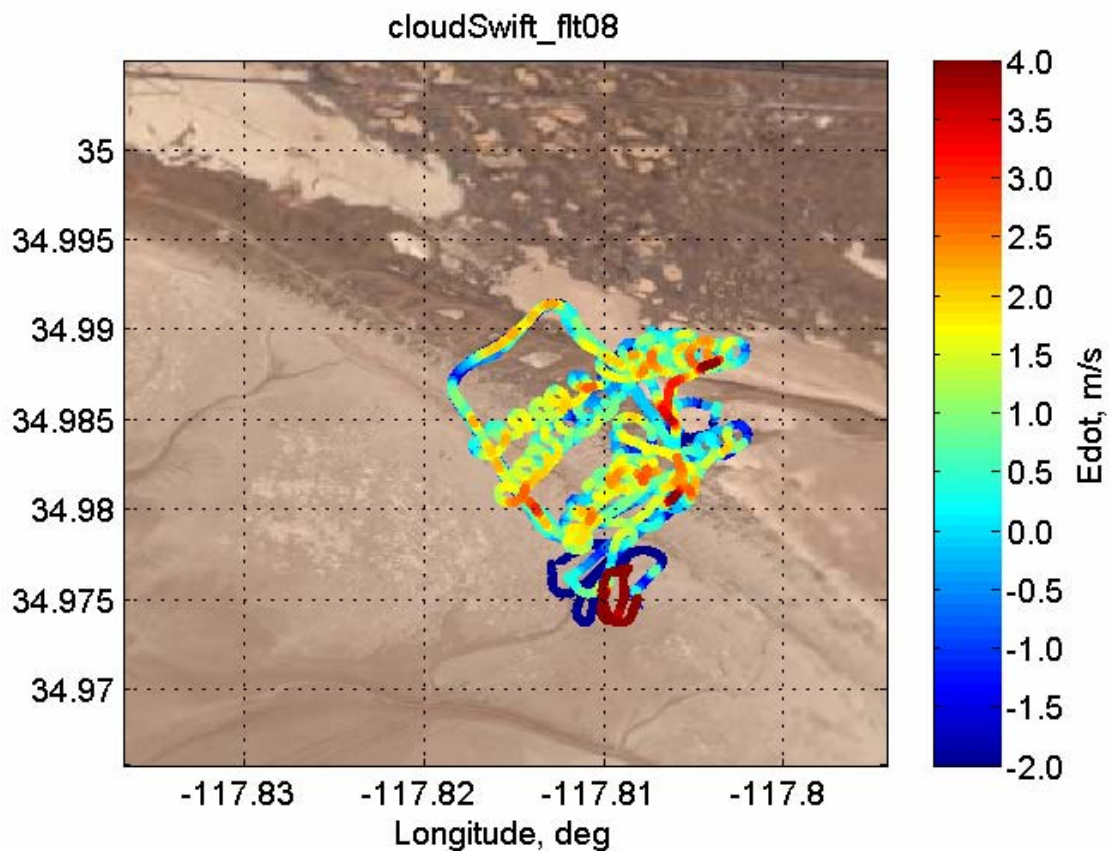


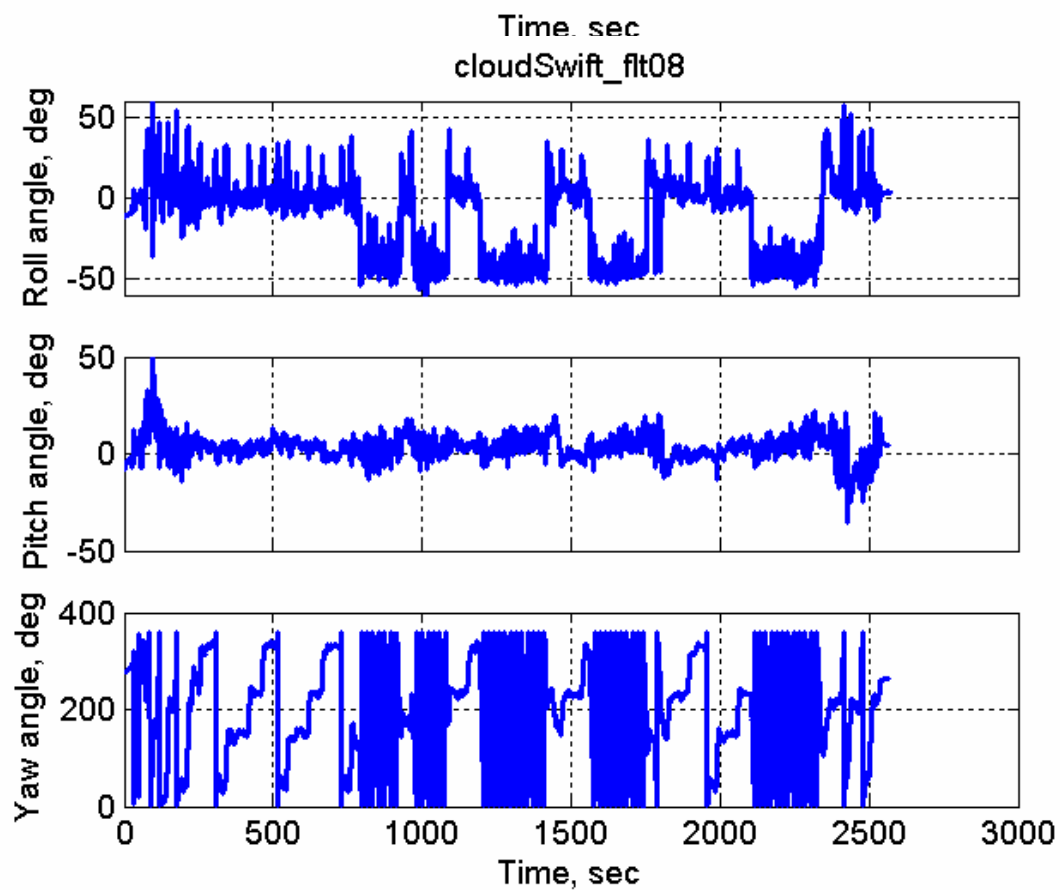
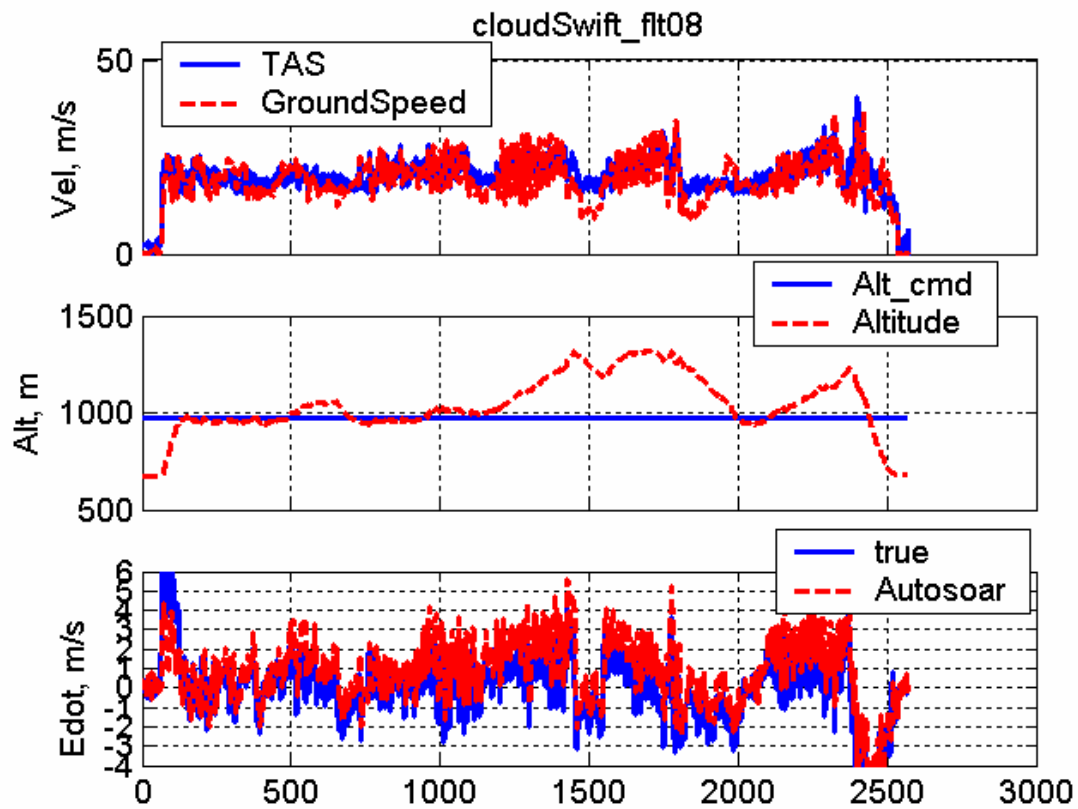


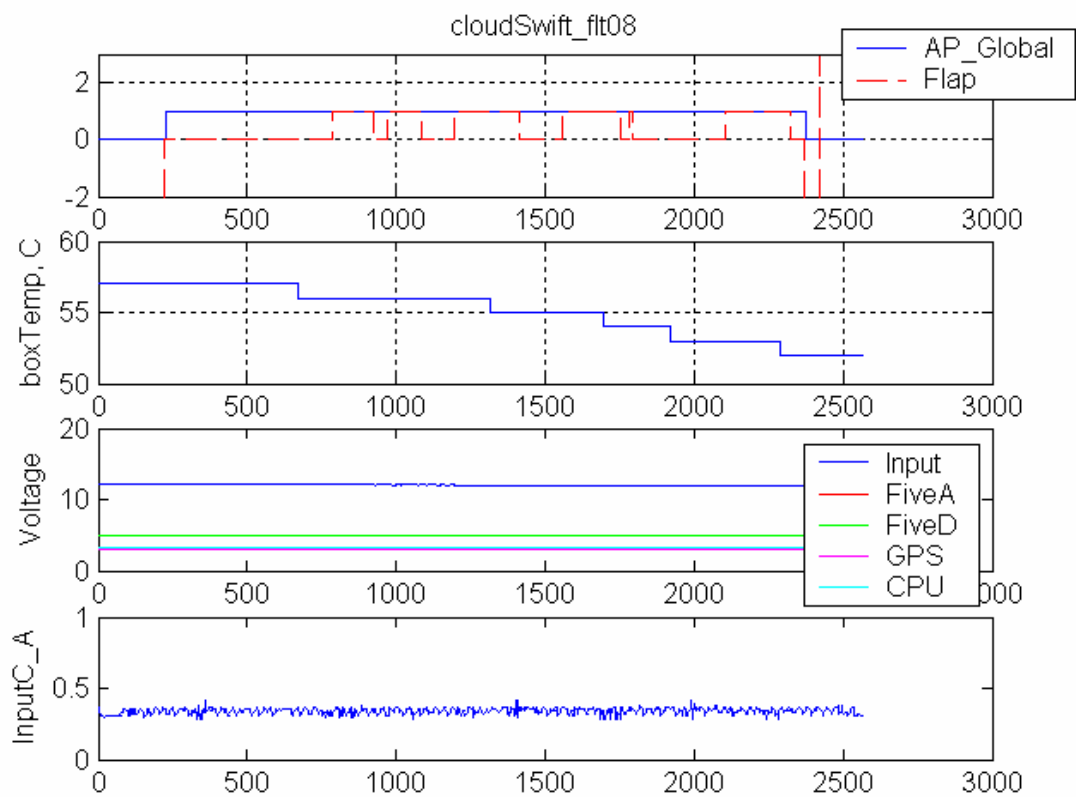
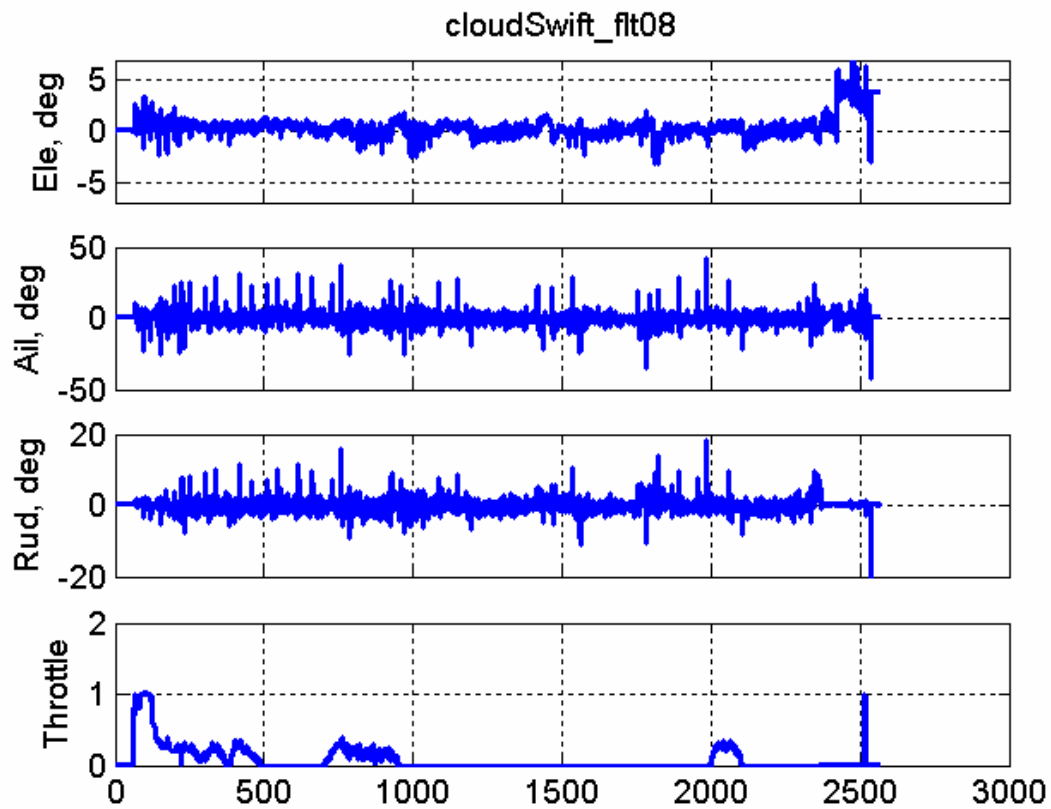
Flight 8

Flight 8 was the first time the autonomous soaring algorithms worked properly. During this flight, the autonomous soaring algorithms detected and centered 5 thermals. Speed increases during thermal centering and poor drift correction remain a problem during this flight.



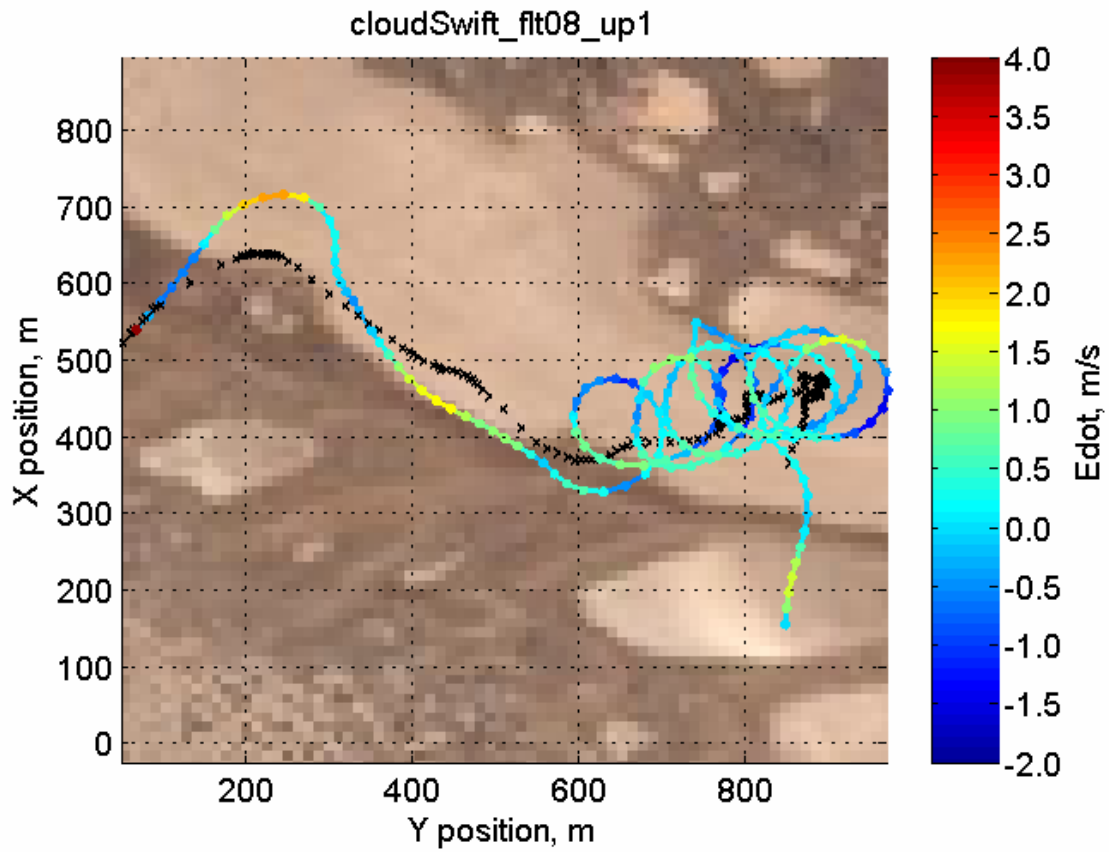


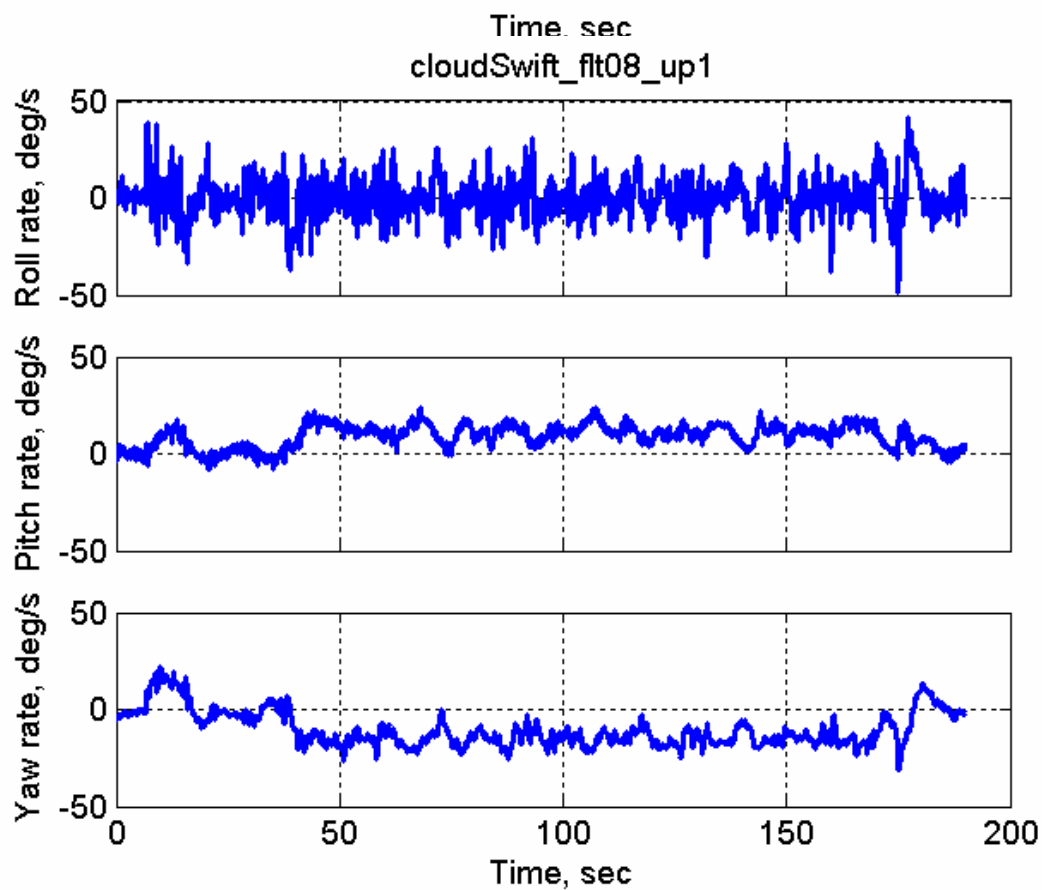
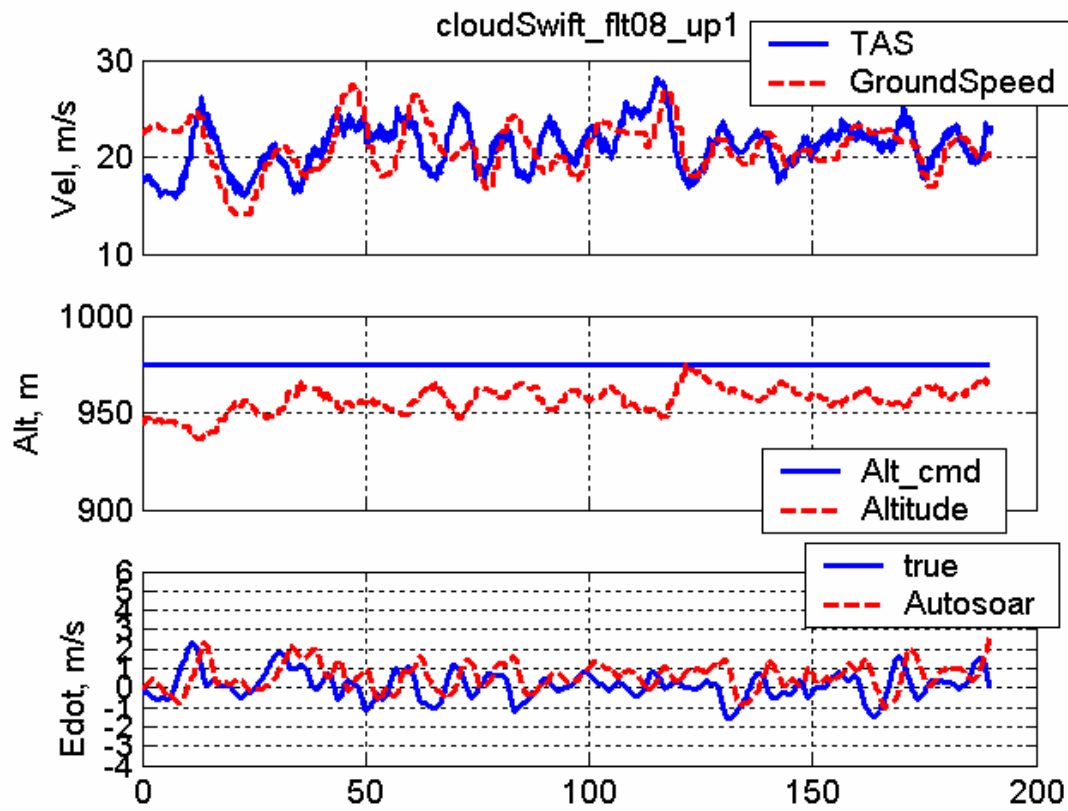


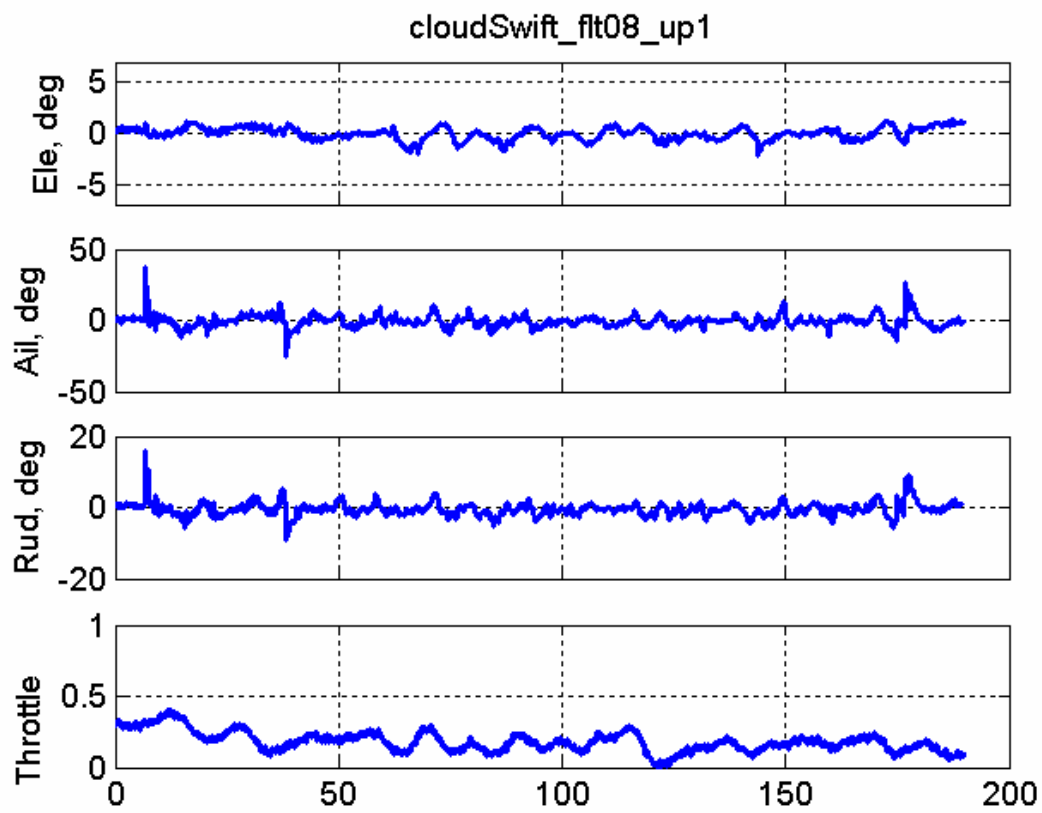
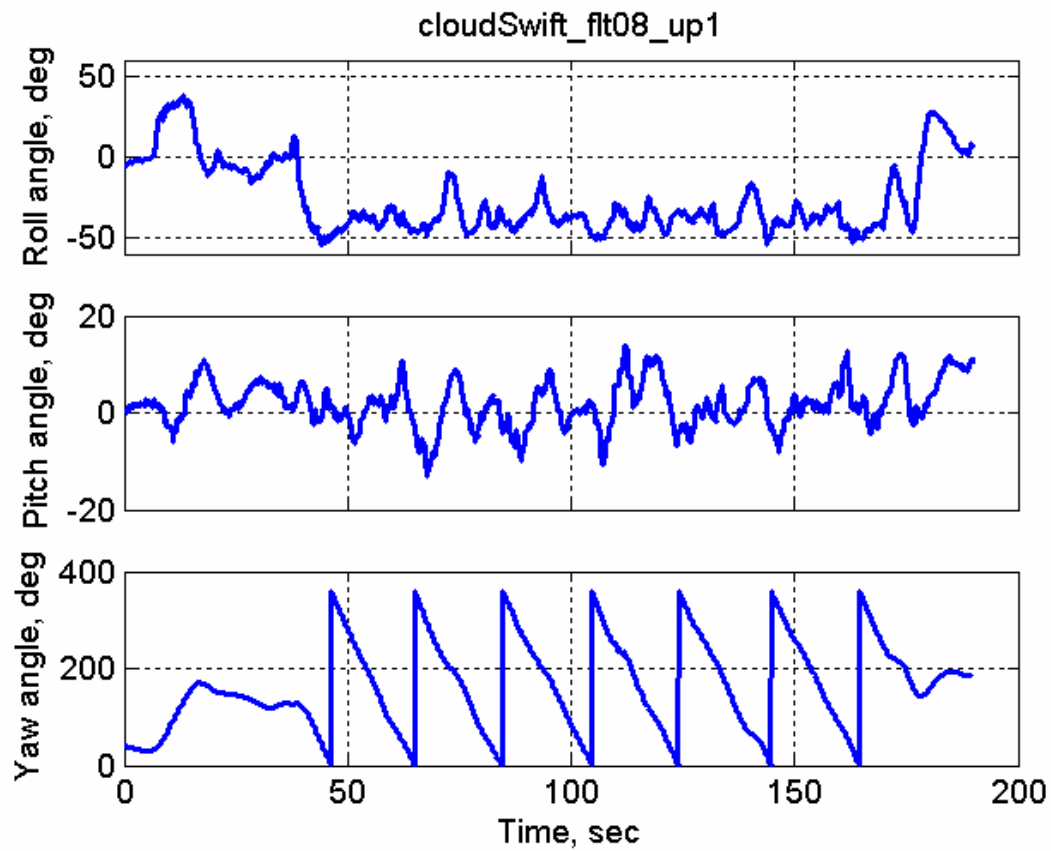


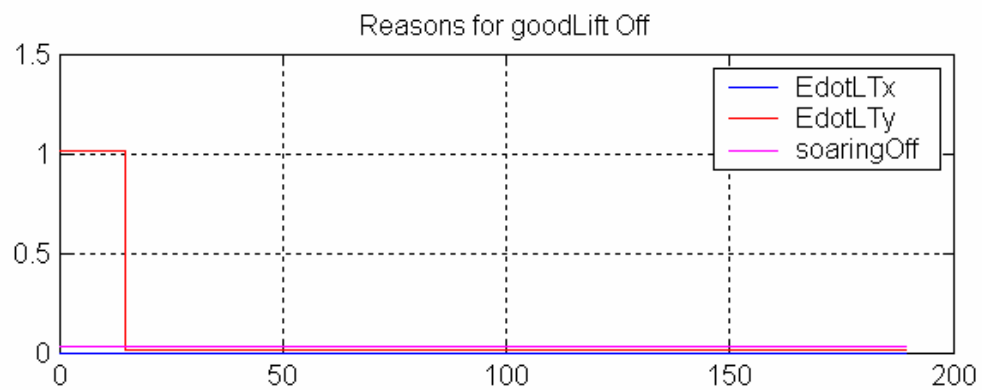
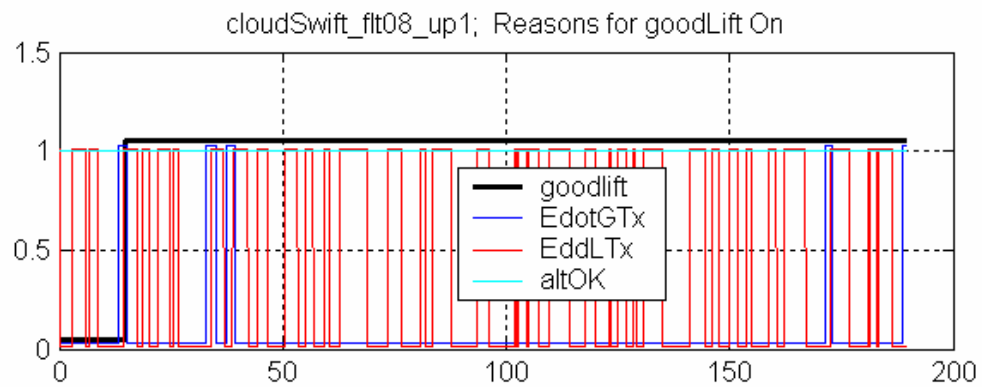
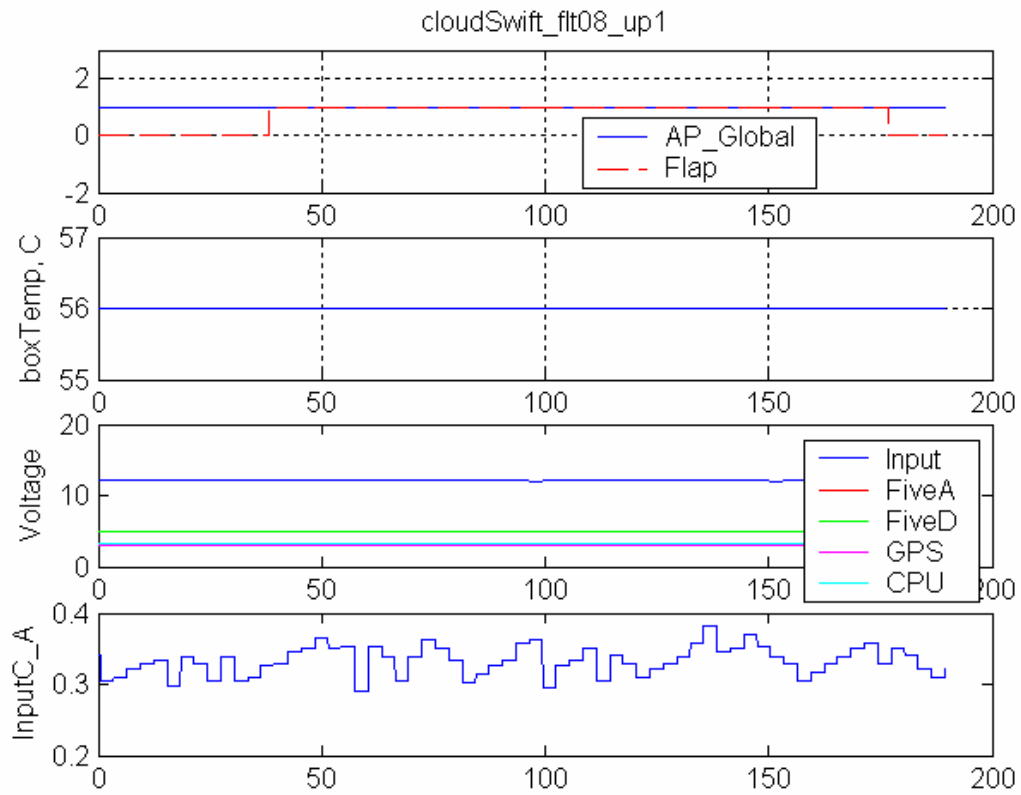
Flight 8, updraft 1

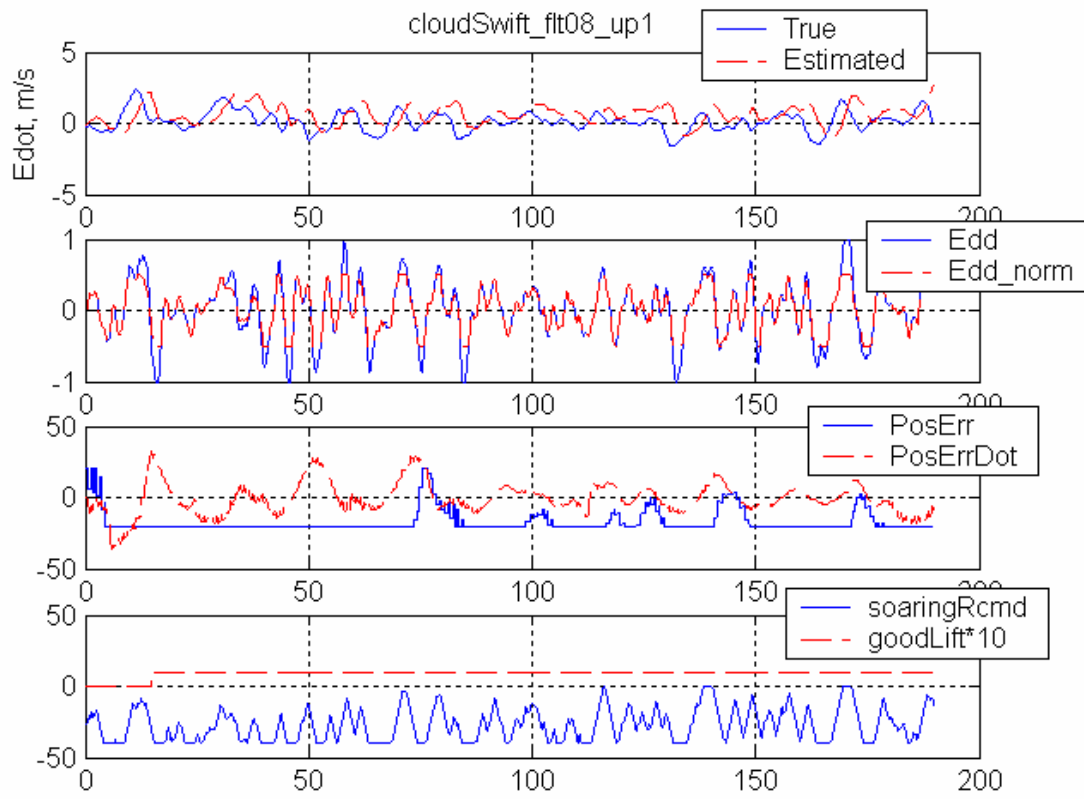
Triggered late and never got back to real thermal. Newer updraft detection logic triggers sooner, as shown.





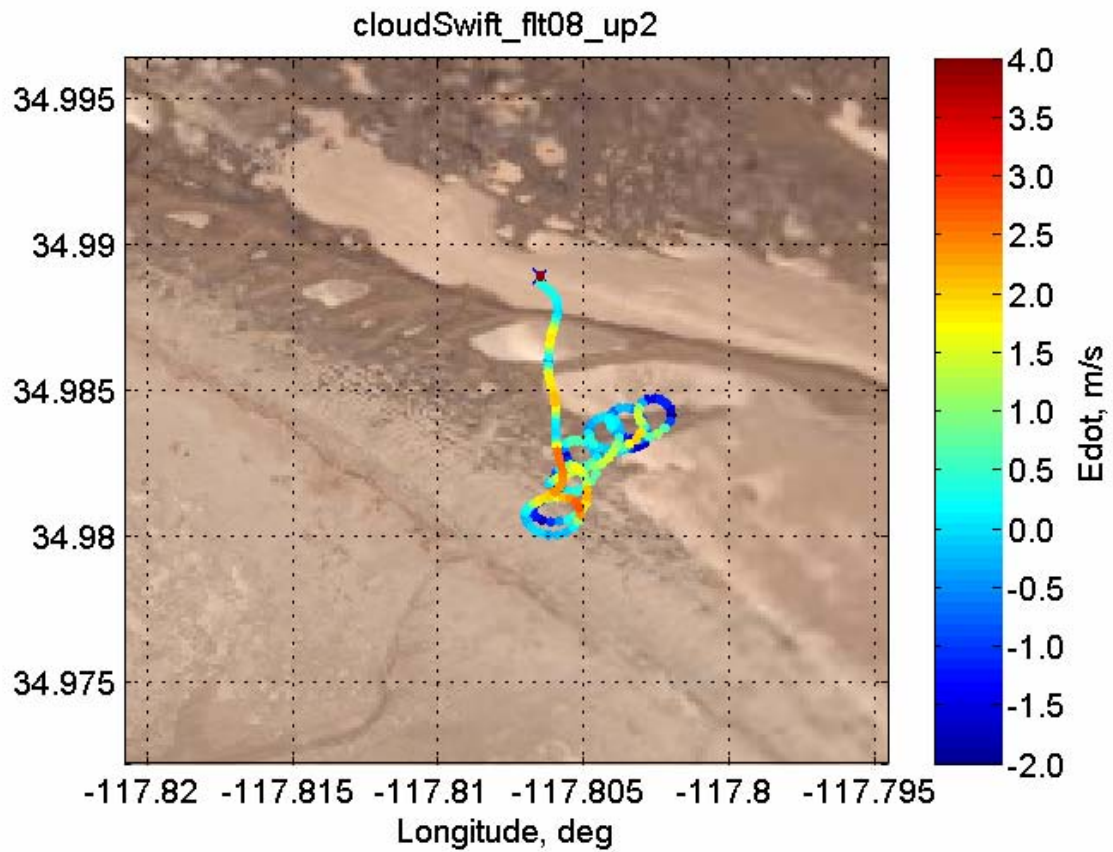


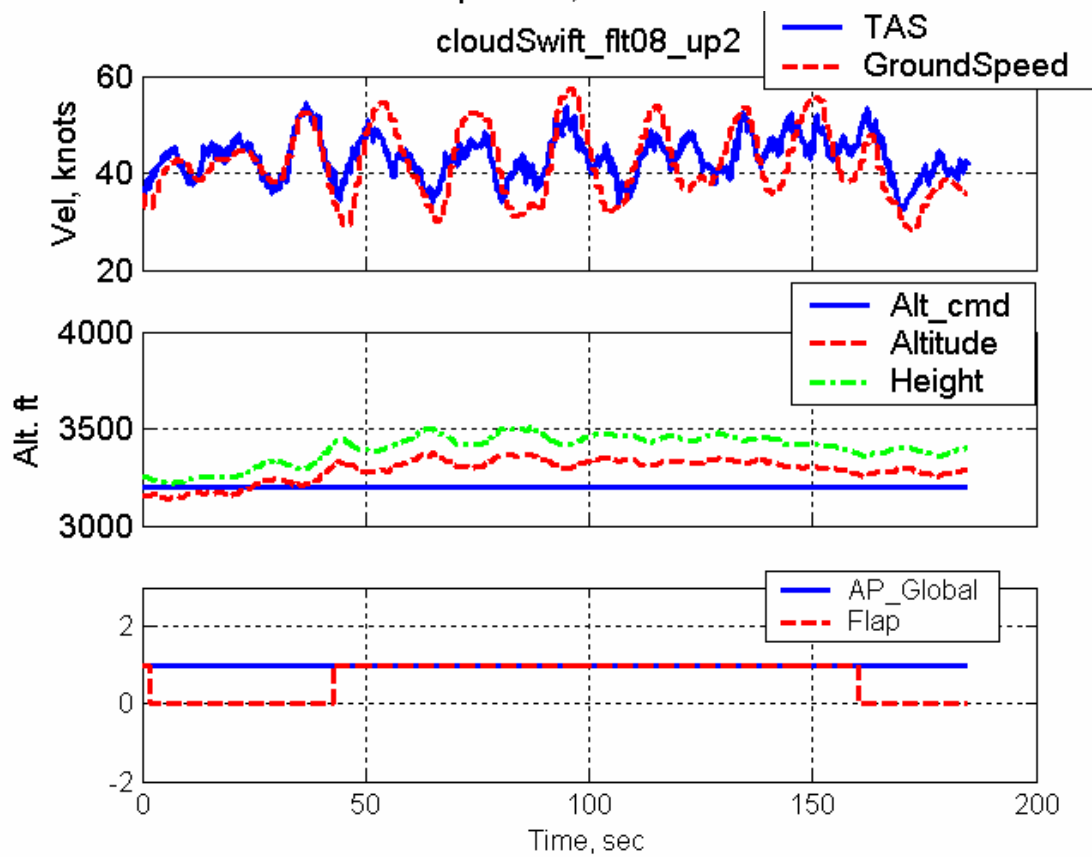
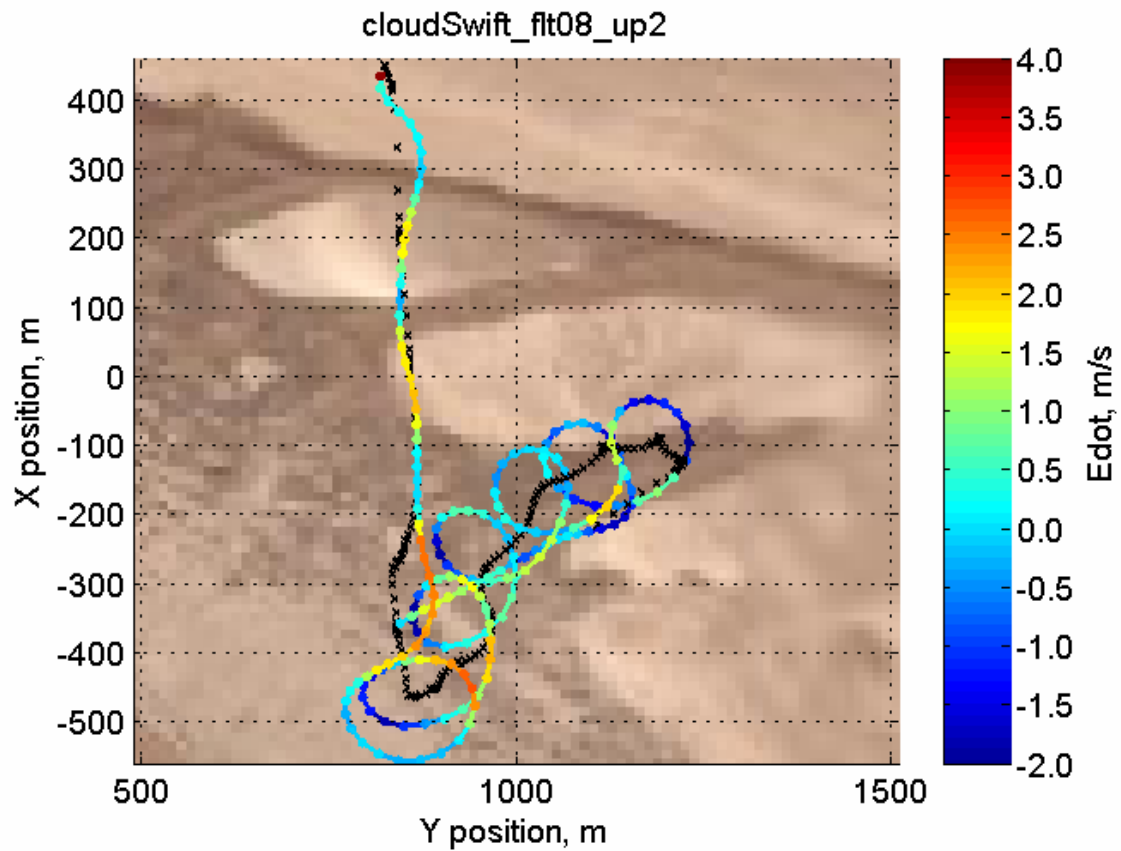


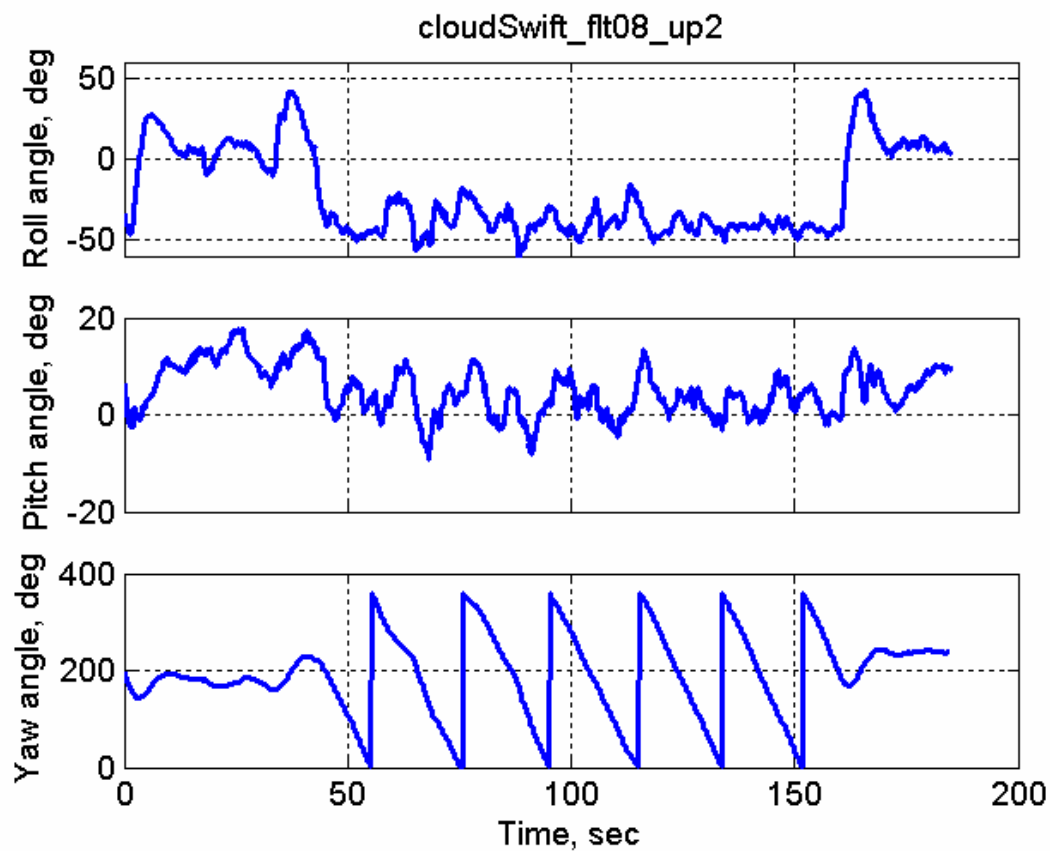
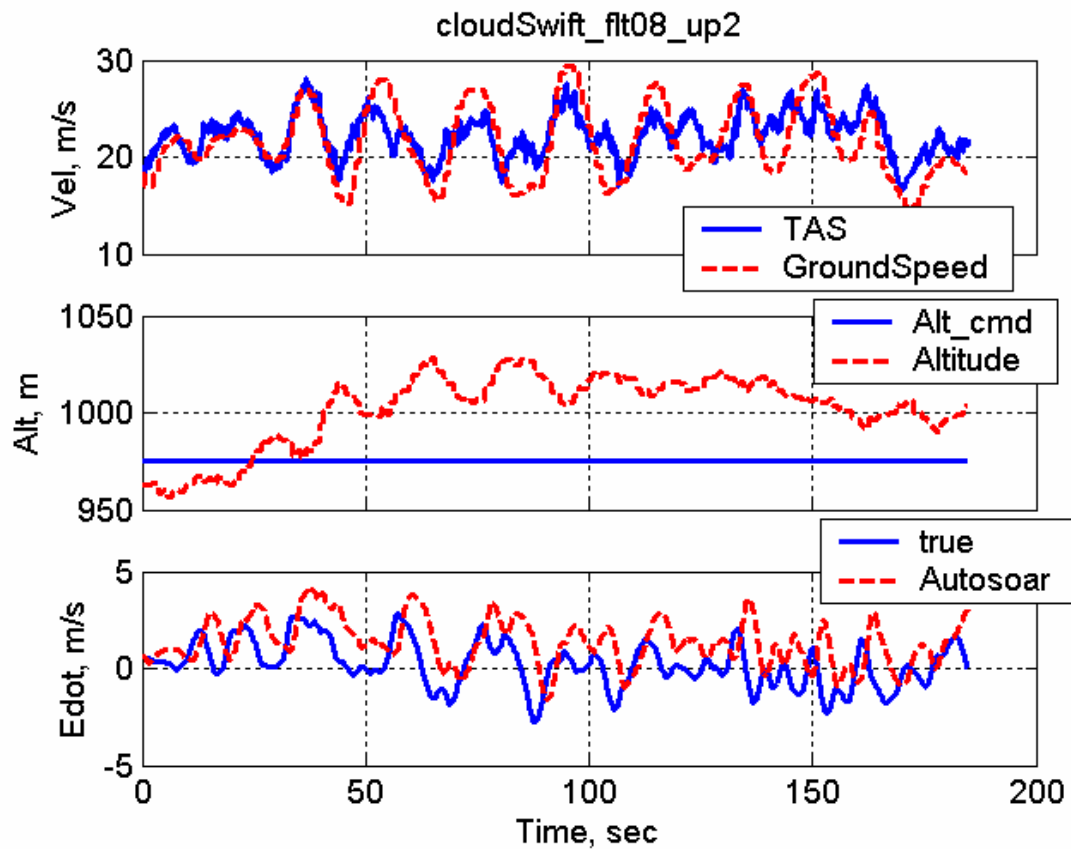


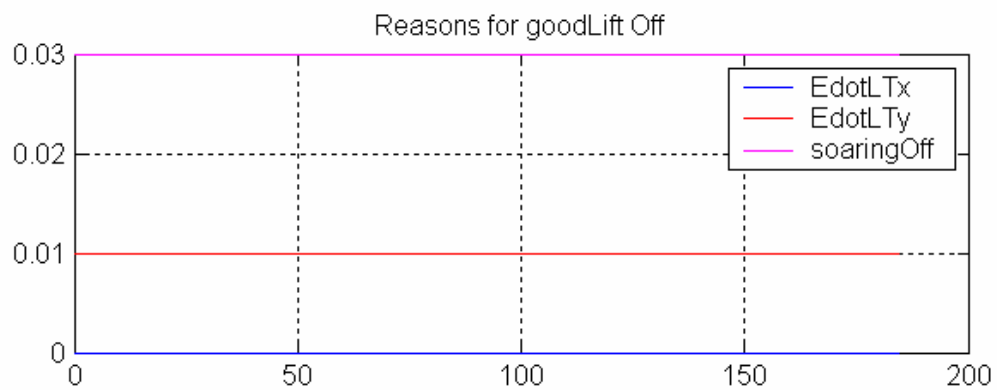
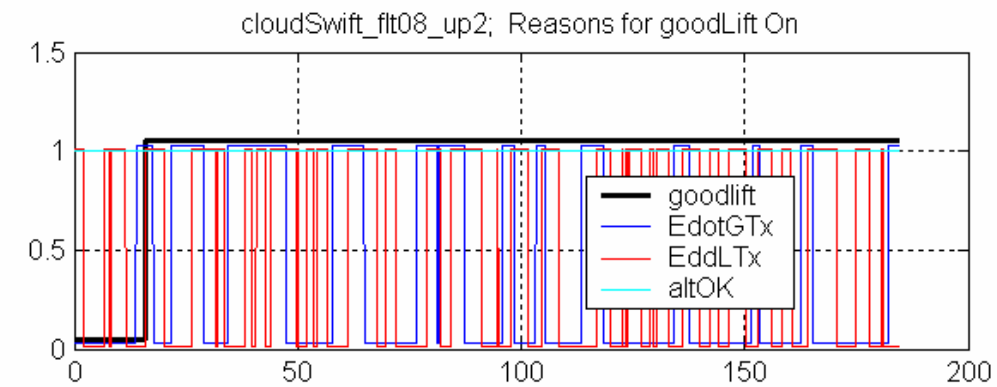
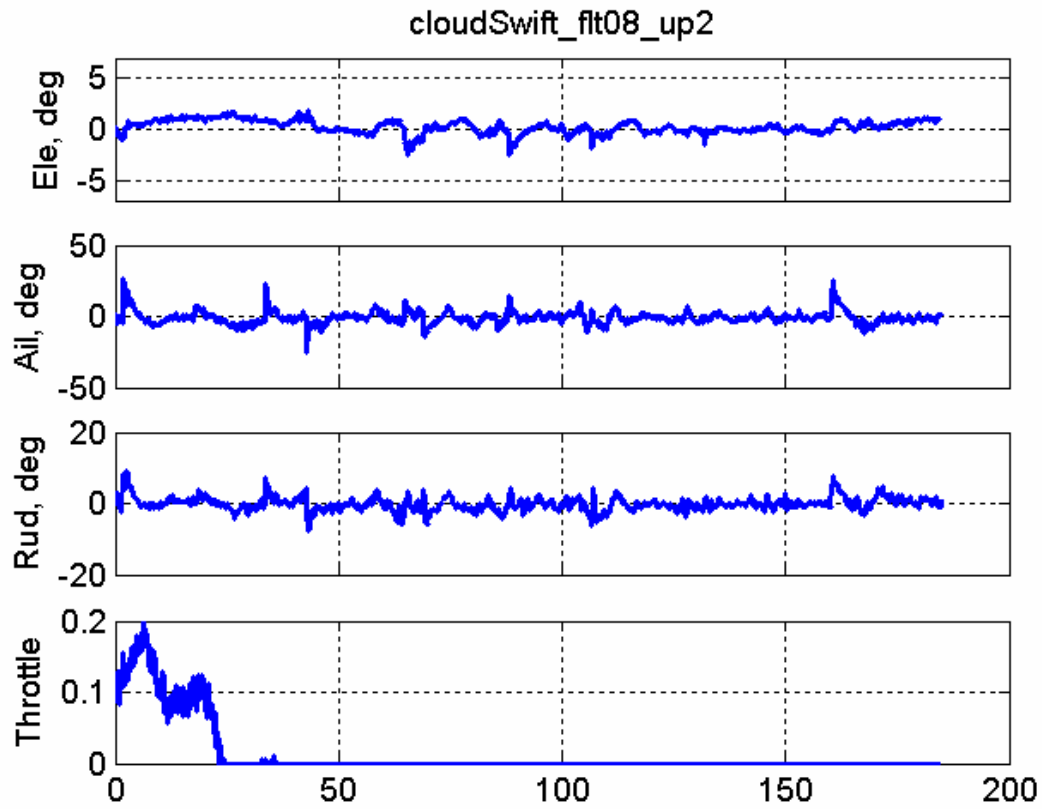
Flight 8, updraft 2

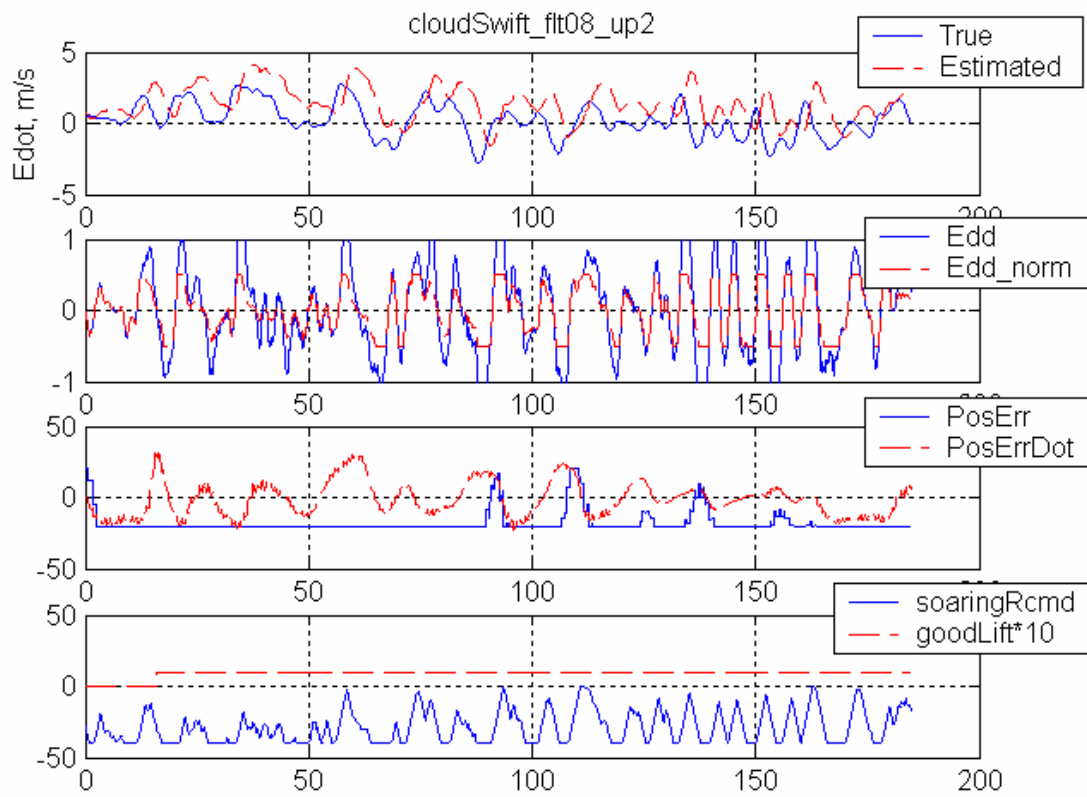
Climbed a little, didn't stay with drifting thermal





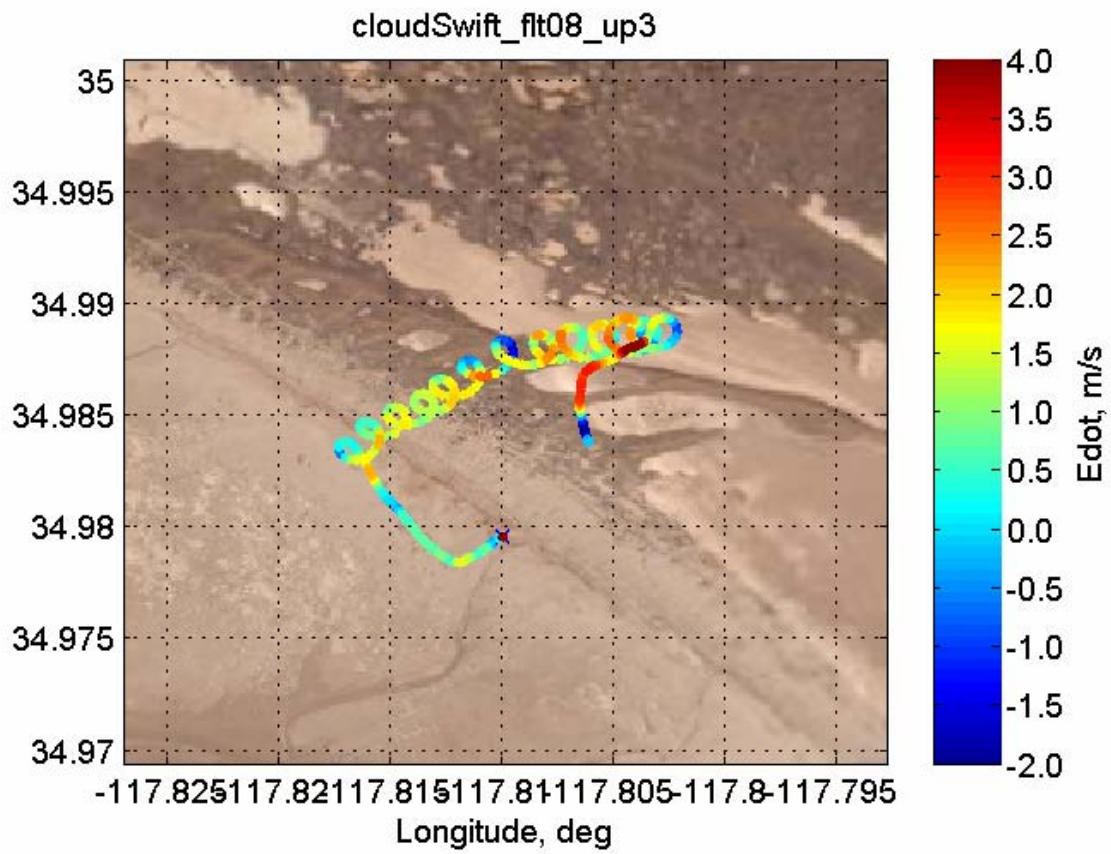


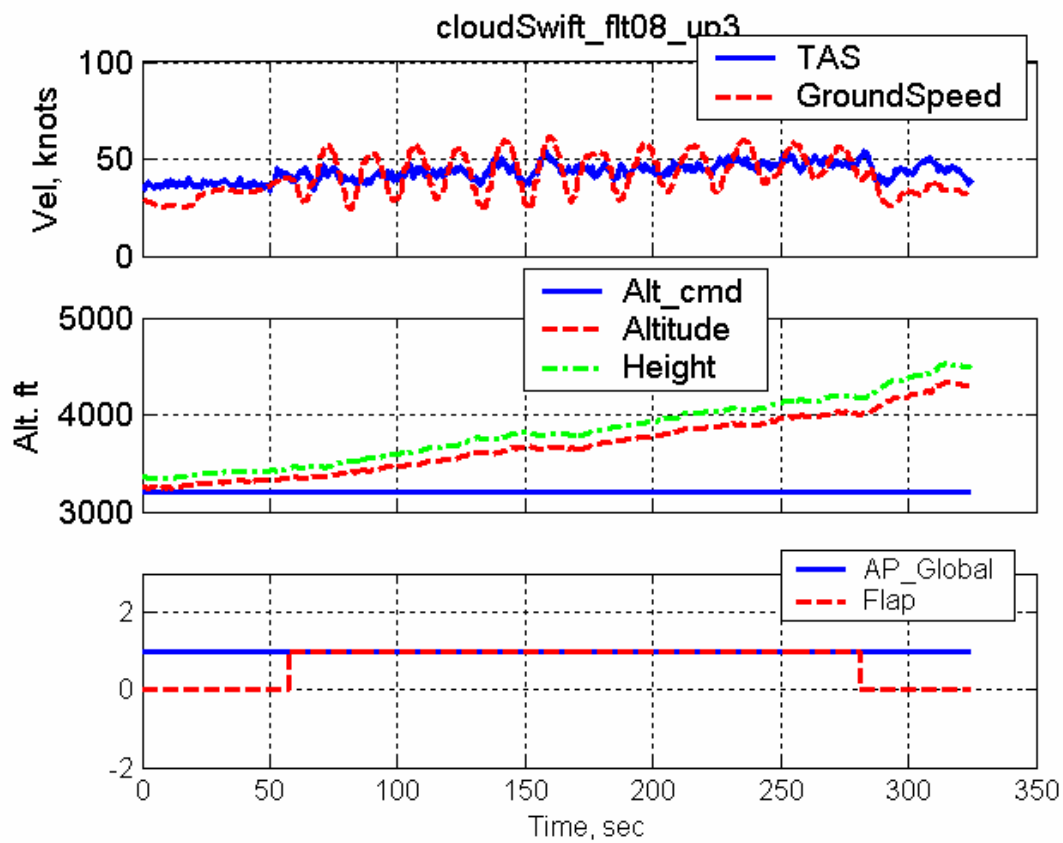
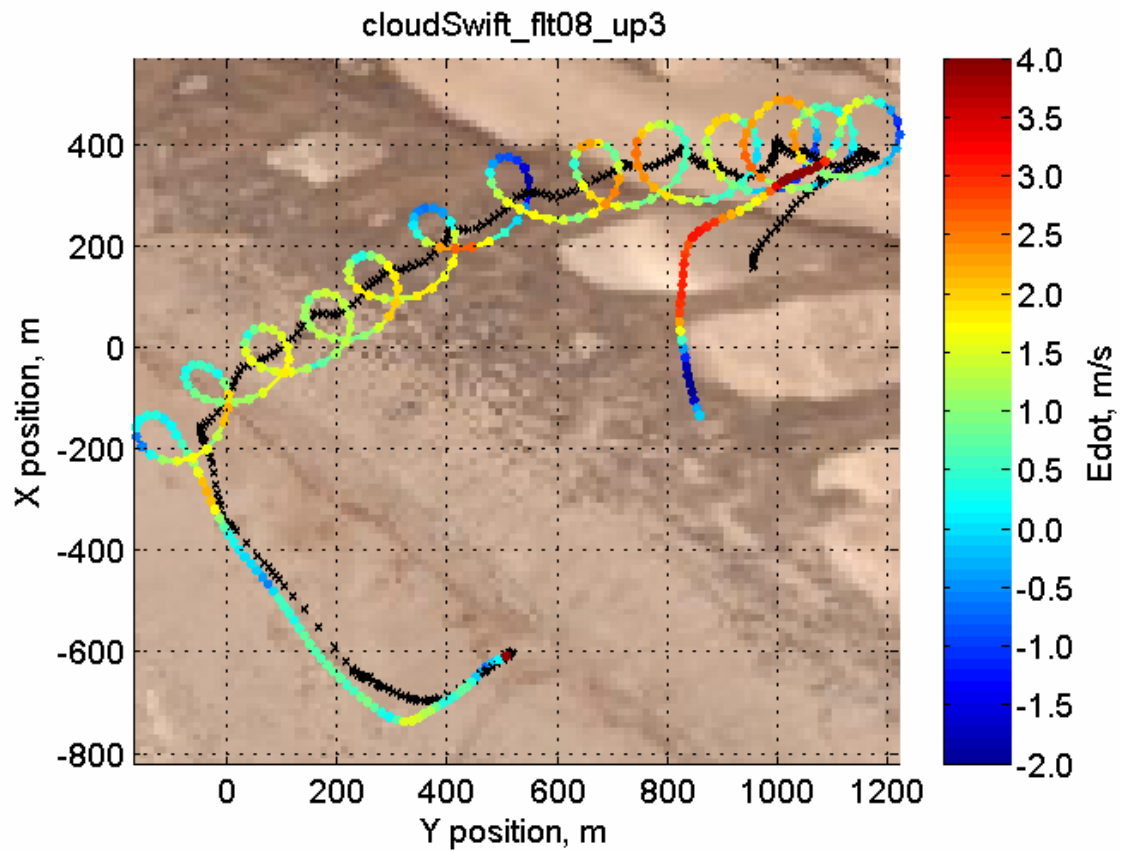


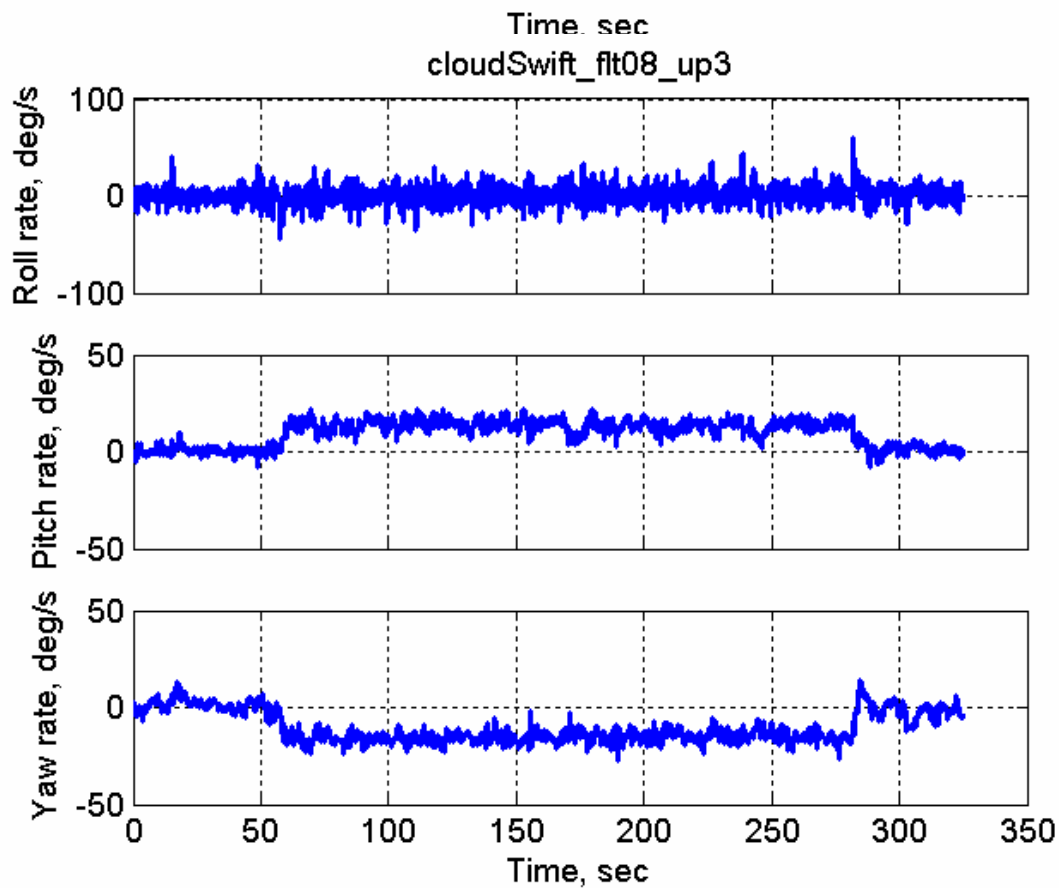
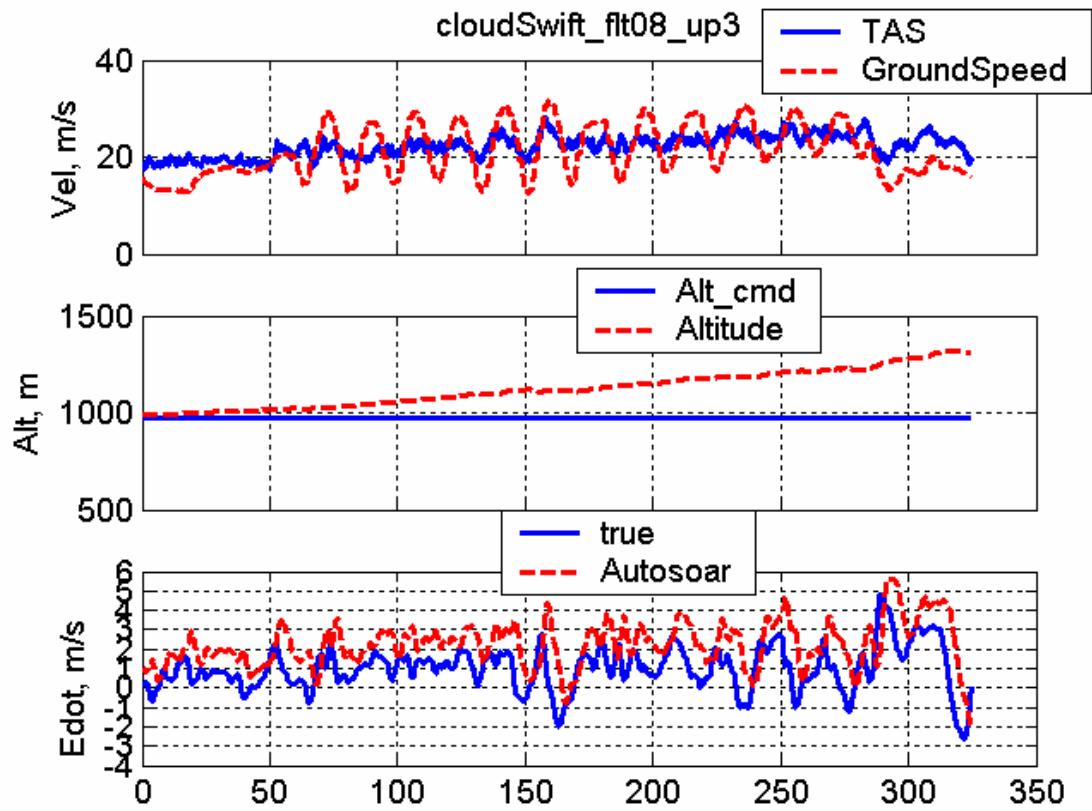


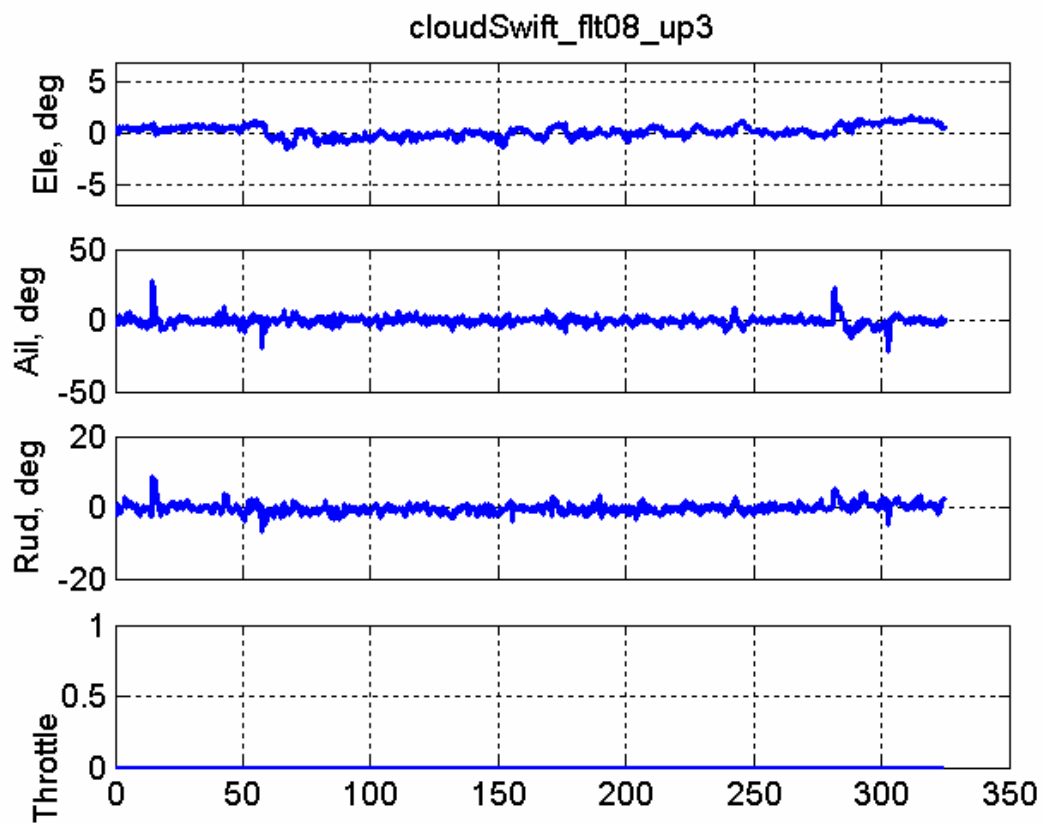
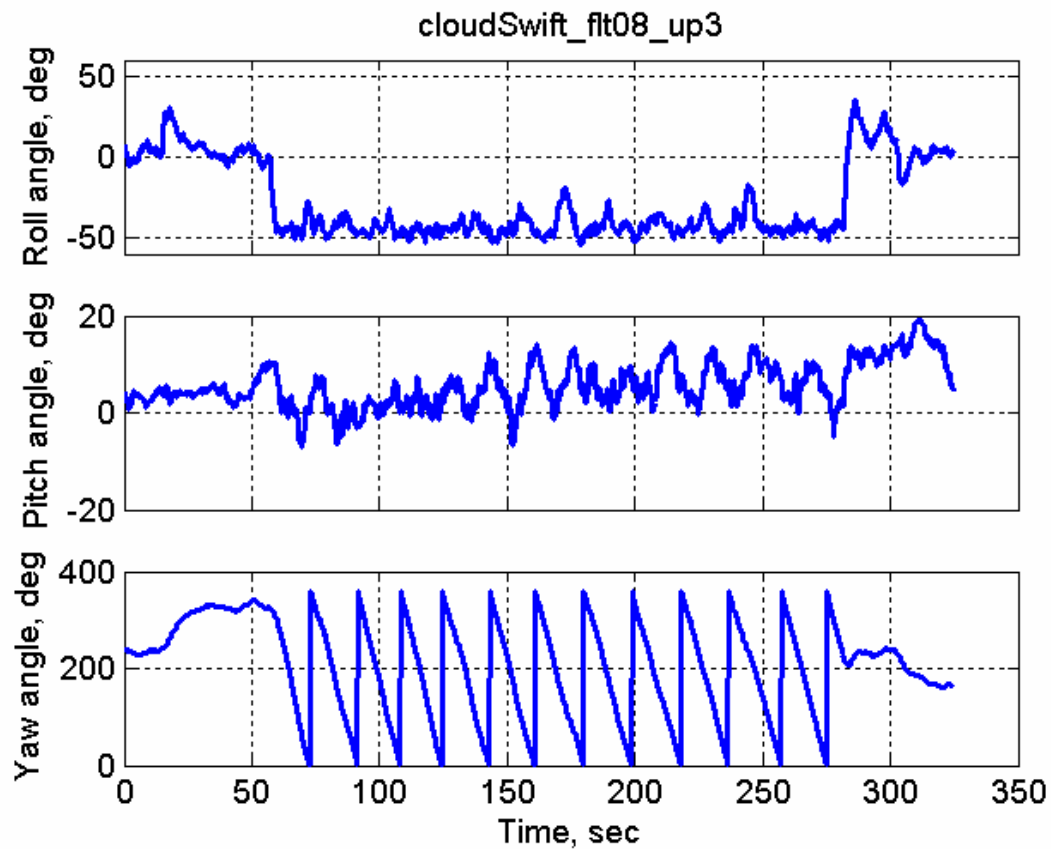
Flight 8, updraft 3

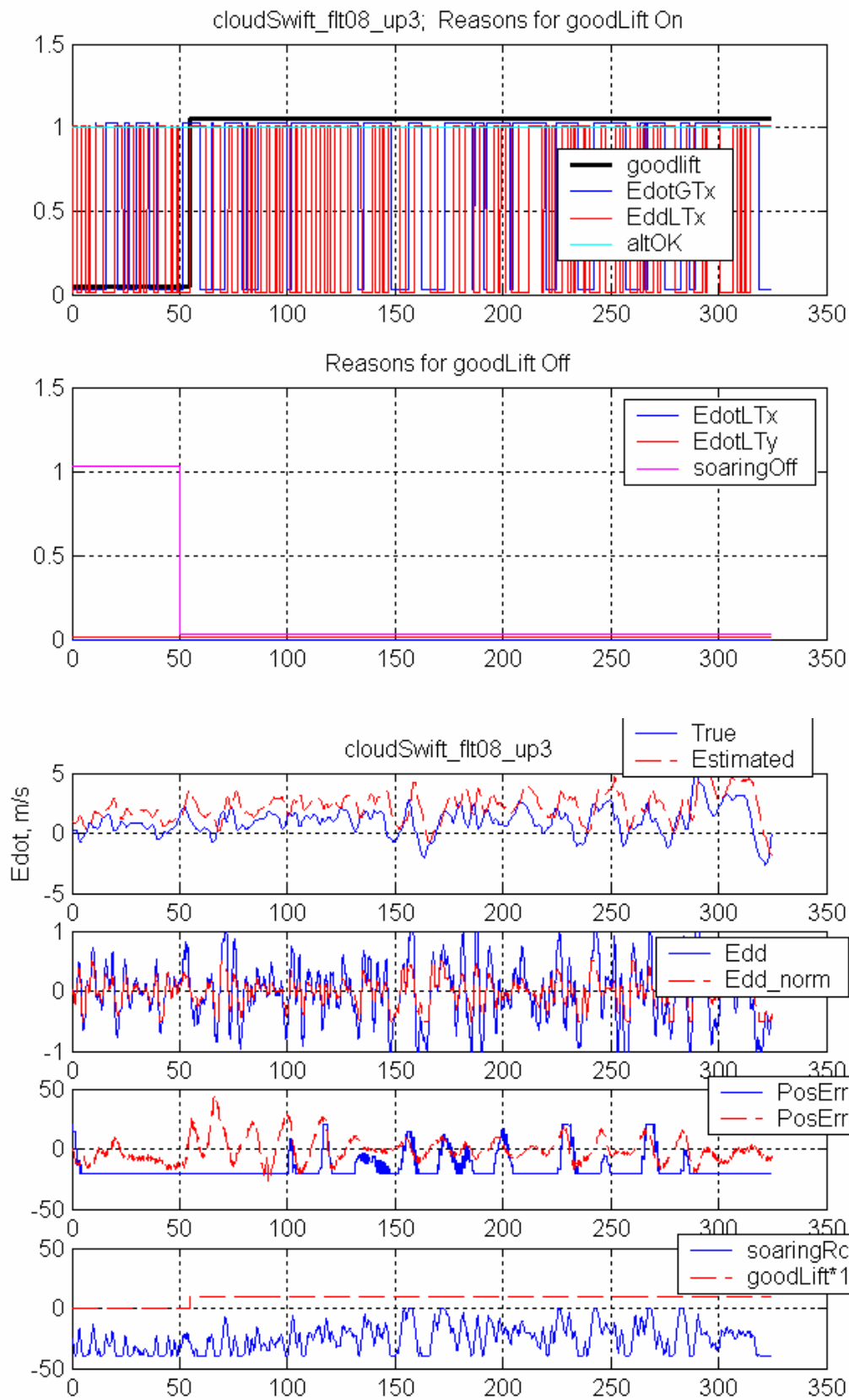
Long duration, better lift at end, fits thermal shape well, dH=1300'

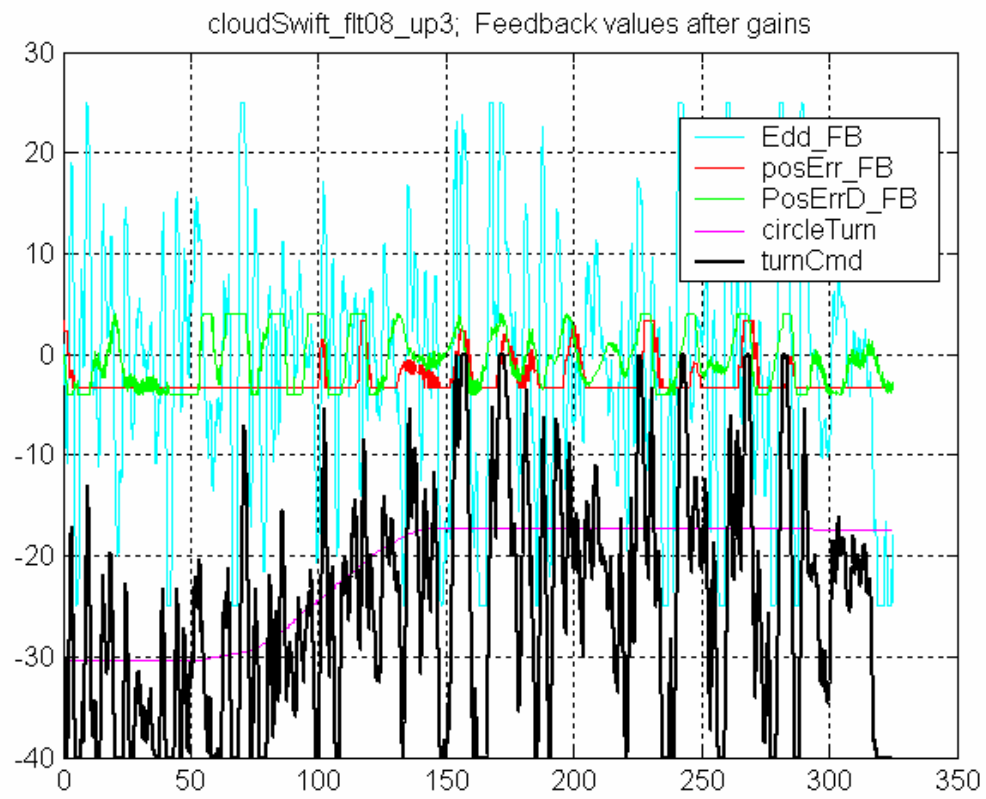






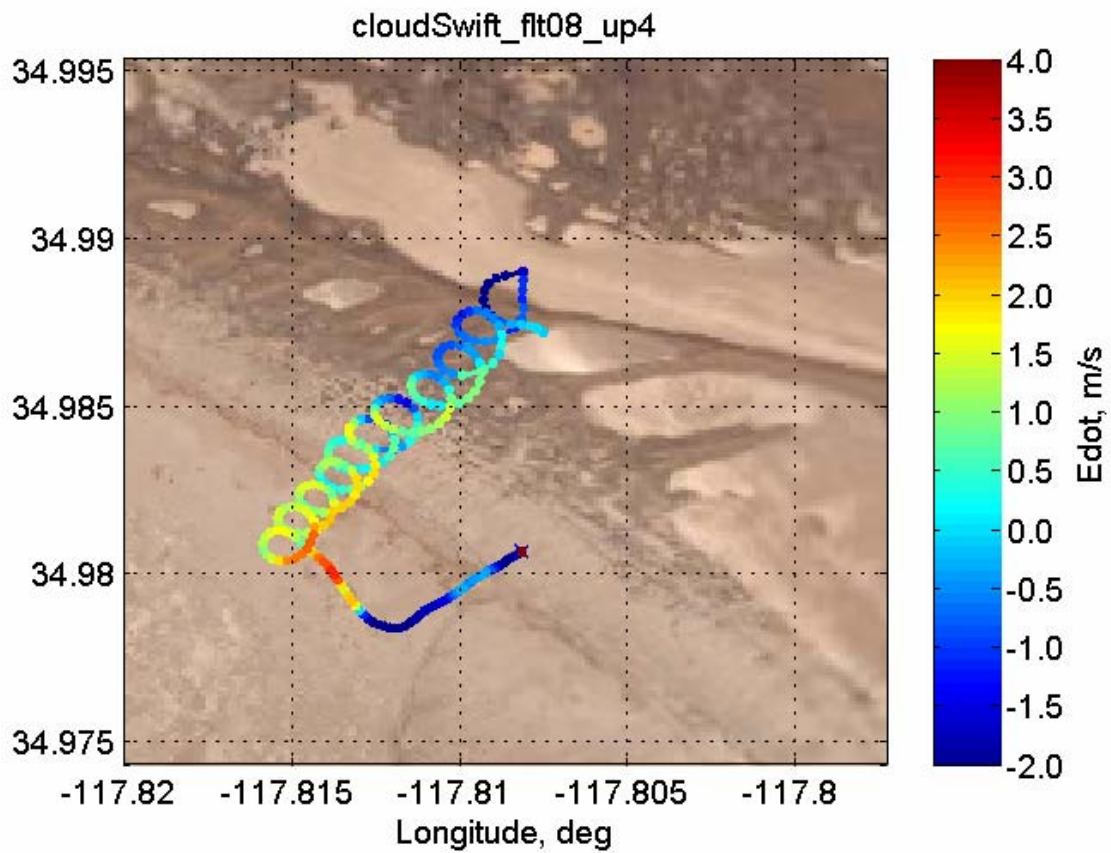


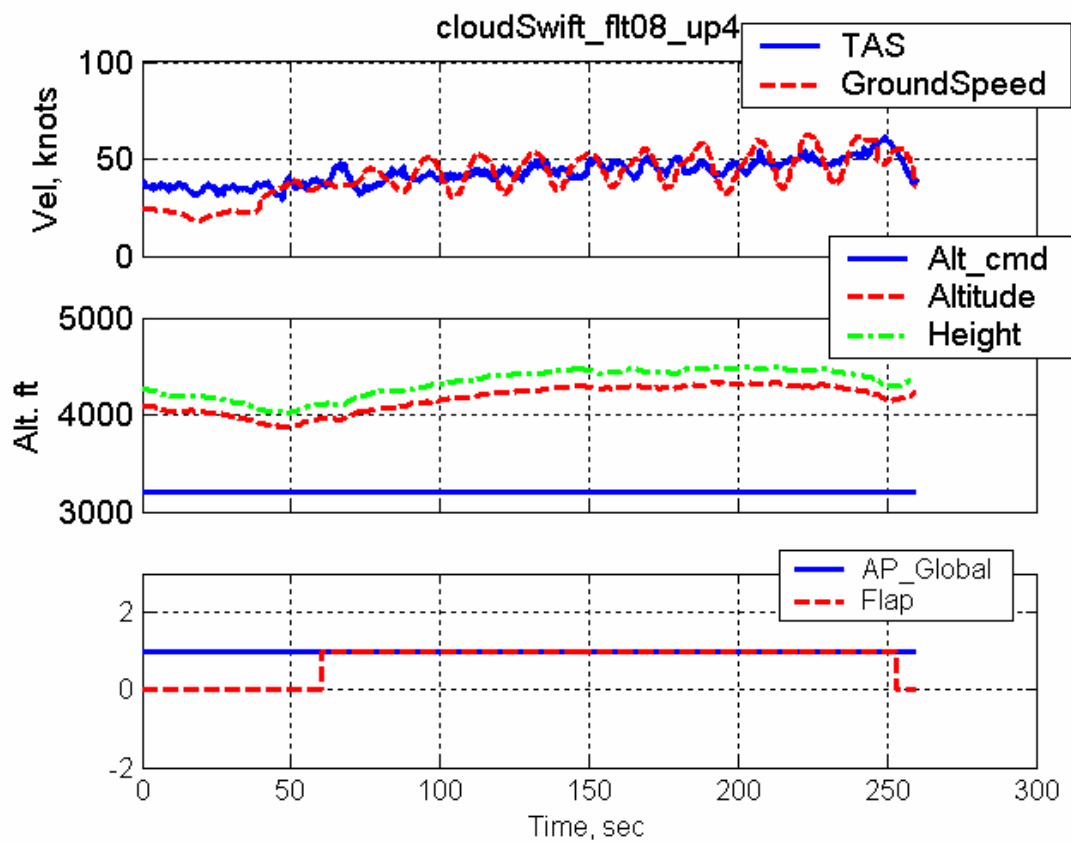
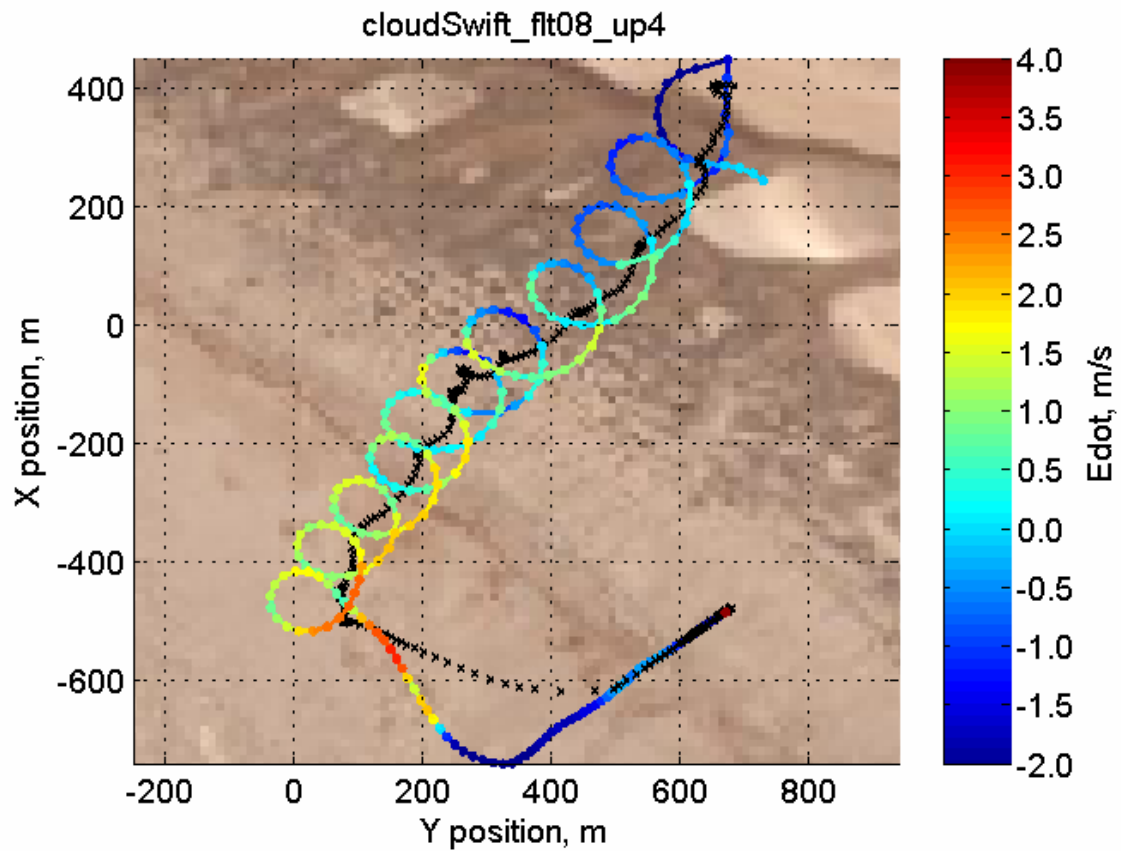


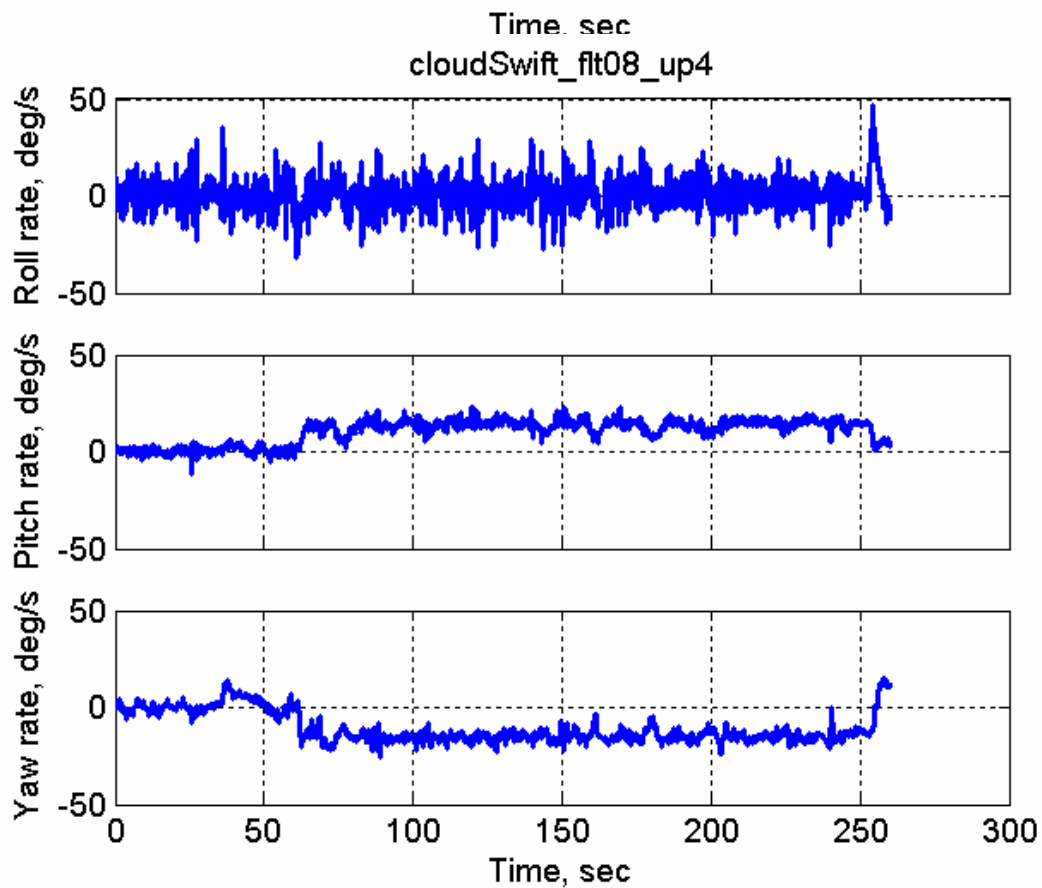
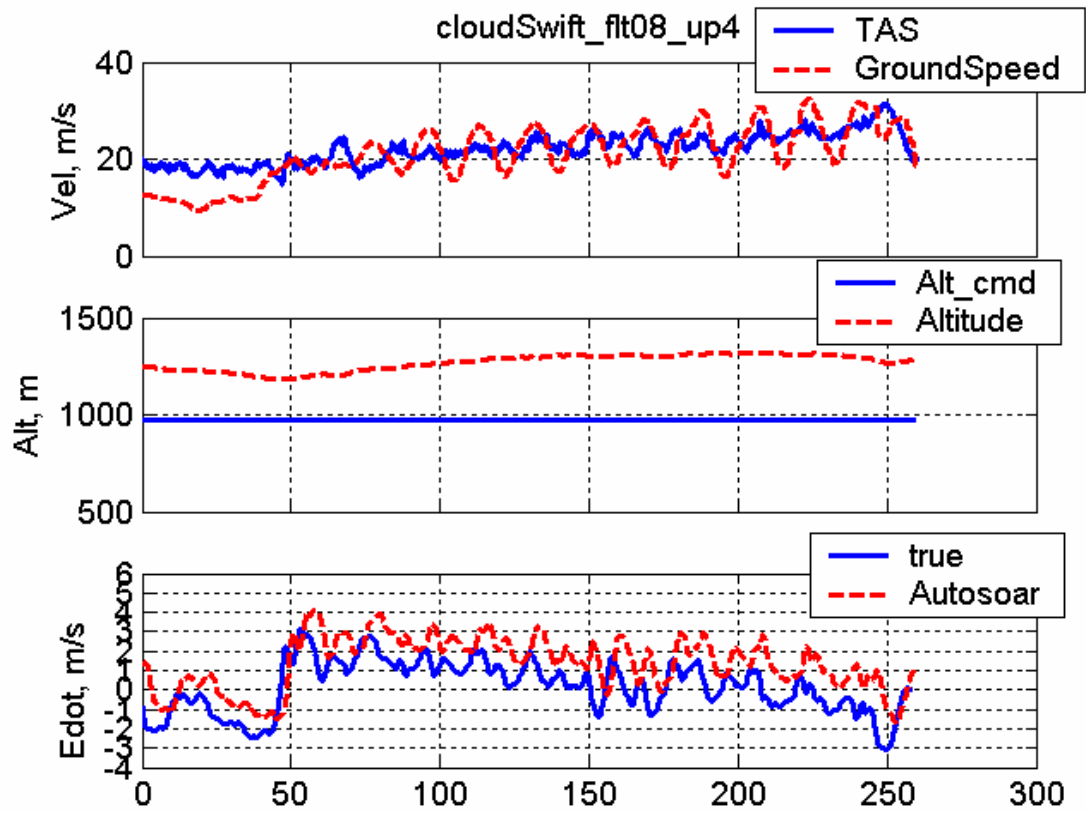


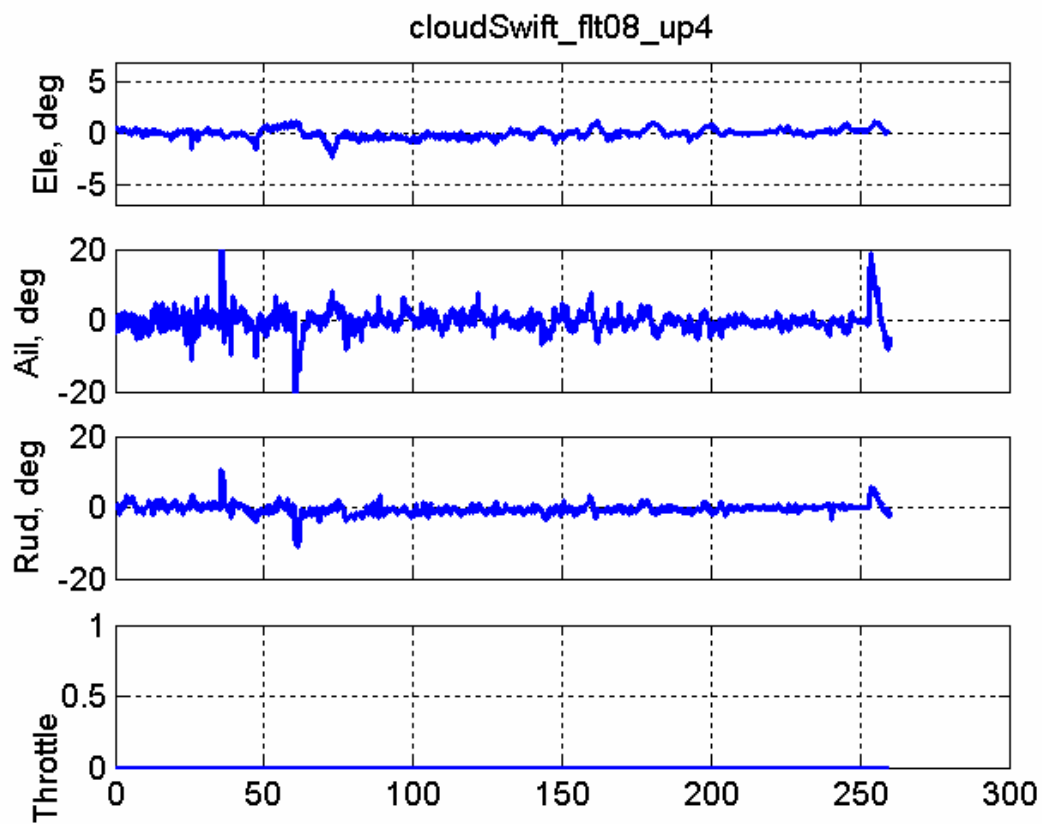
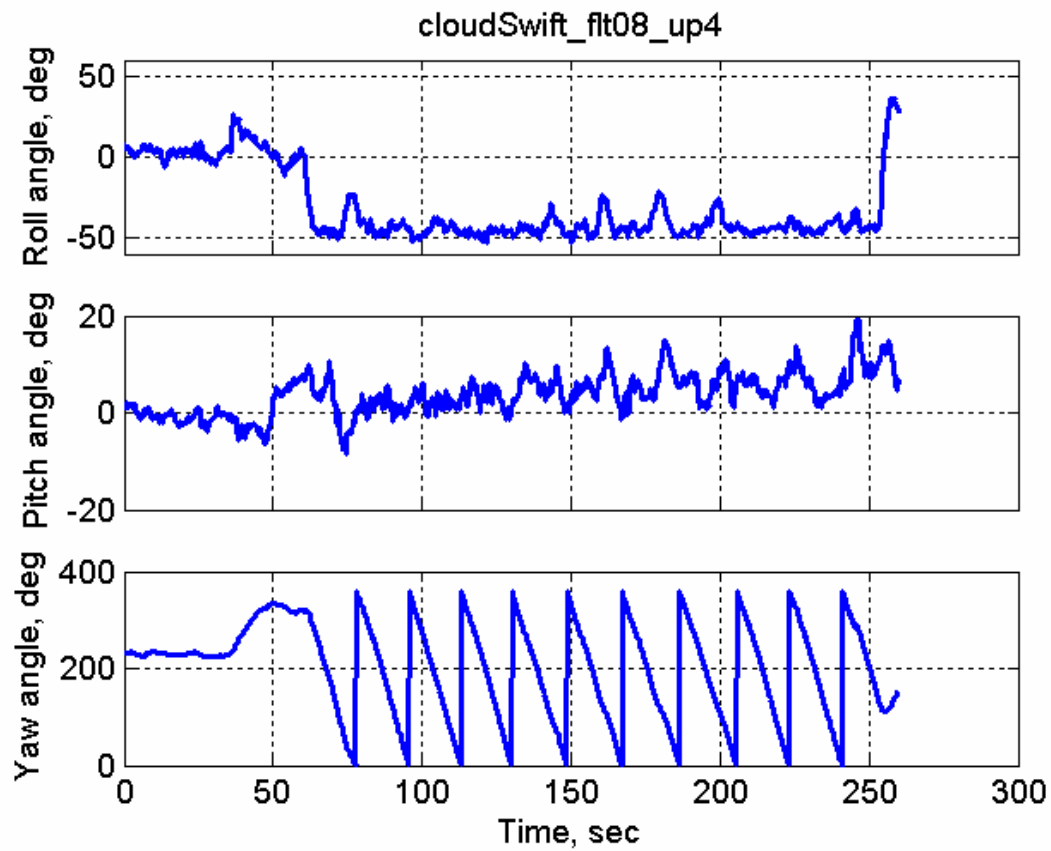
Flight 8, updraft 4

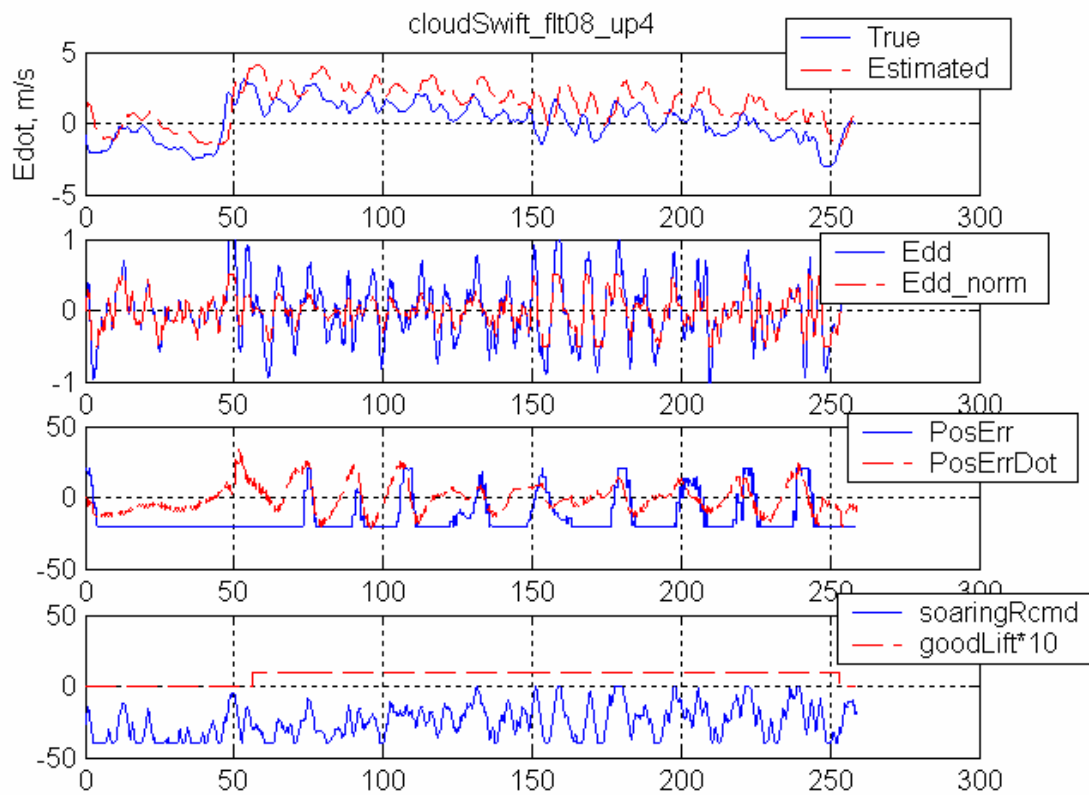
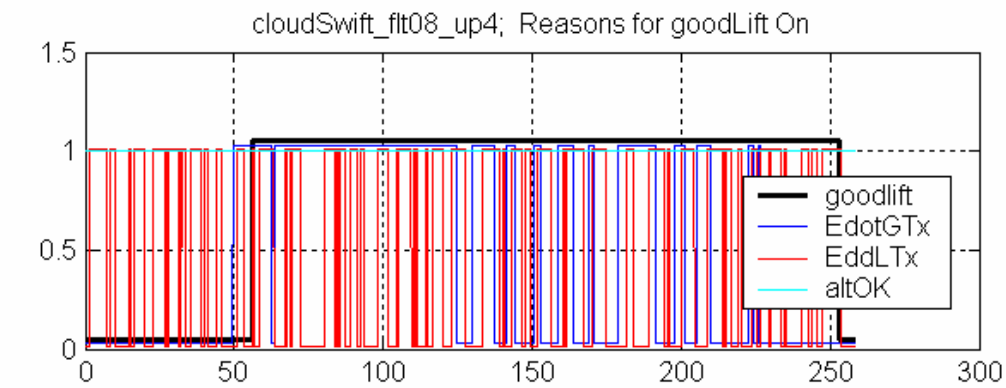
Nice climb in moderate strength thermal. Delays in Edd cause centering to be slightly off.





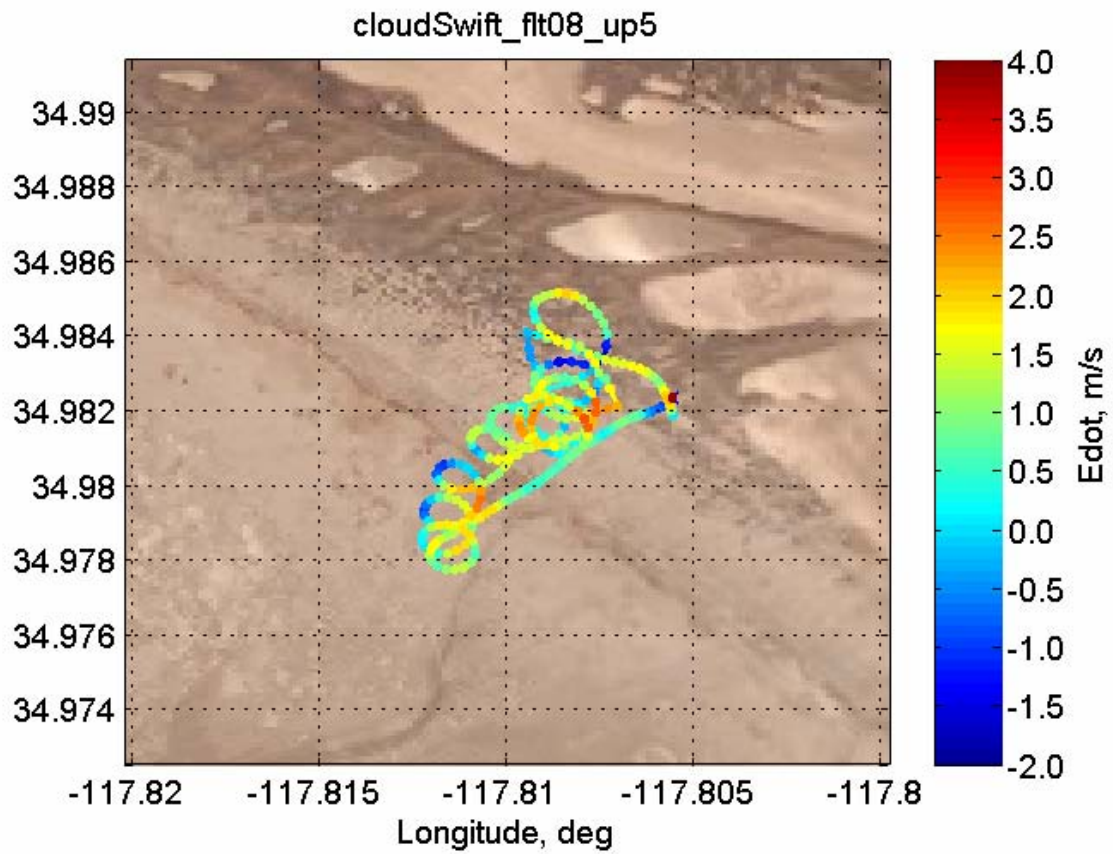


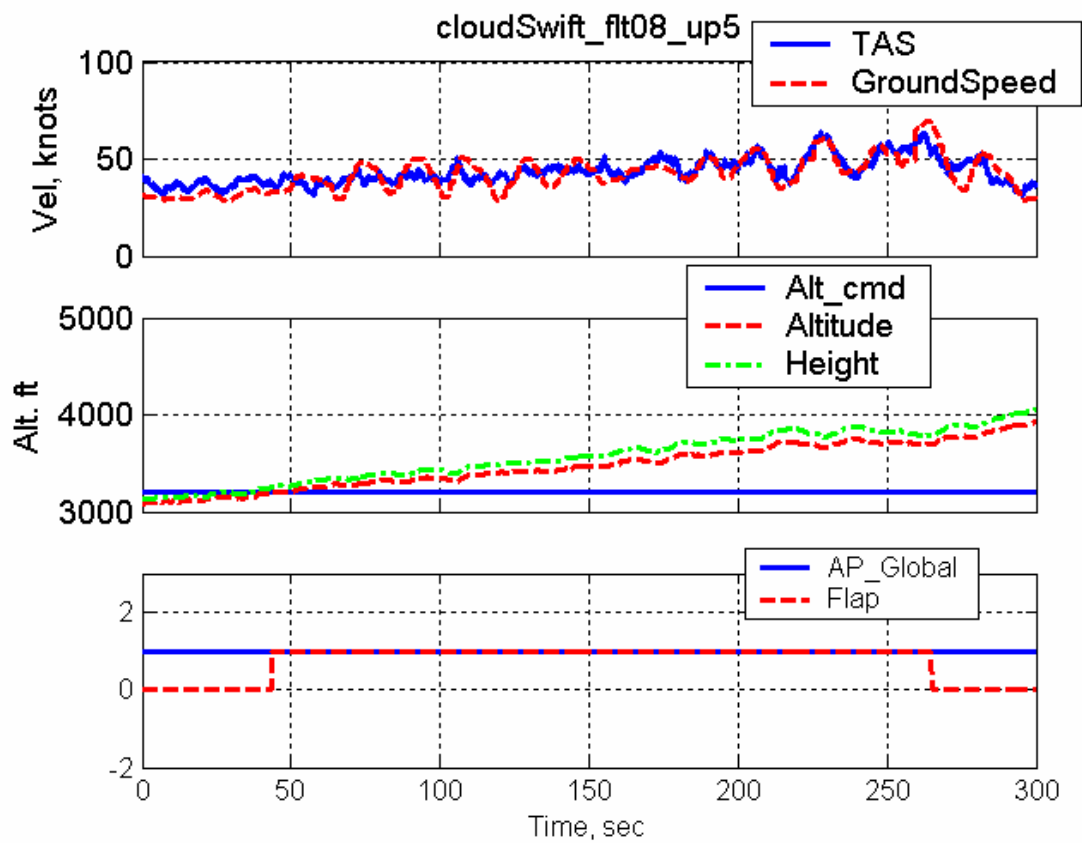
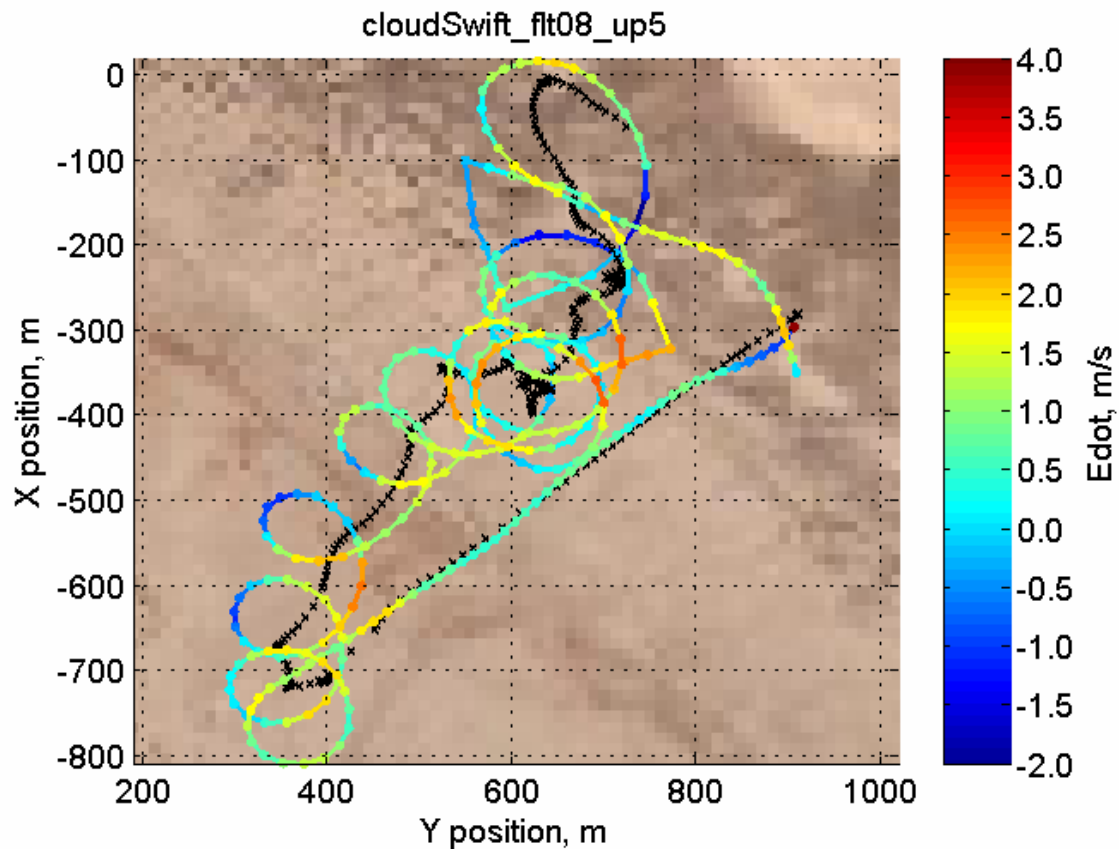


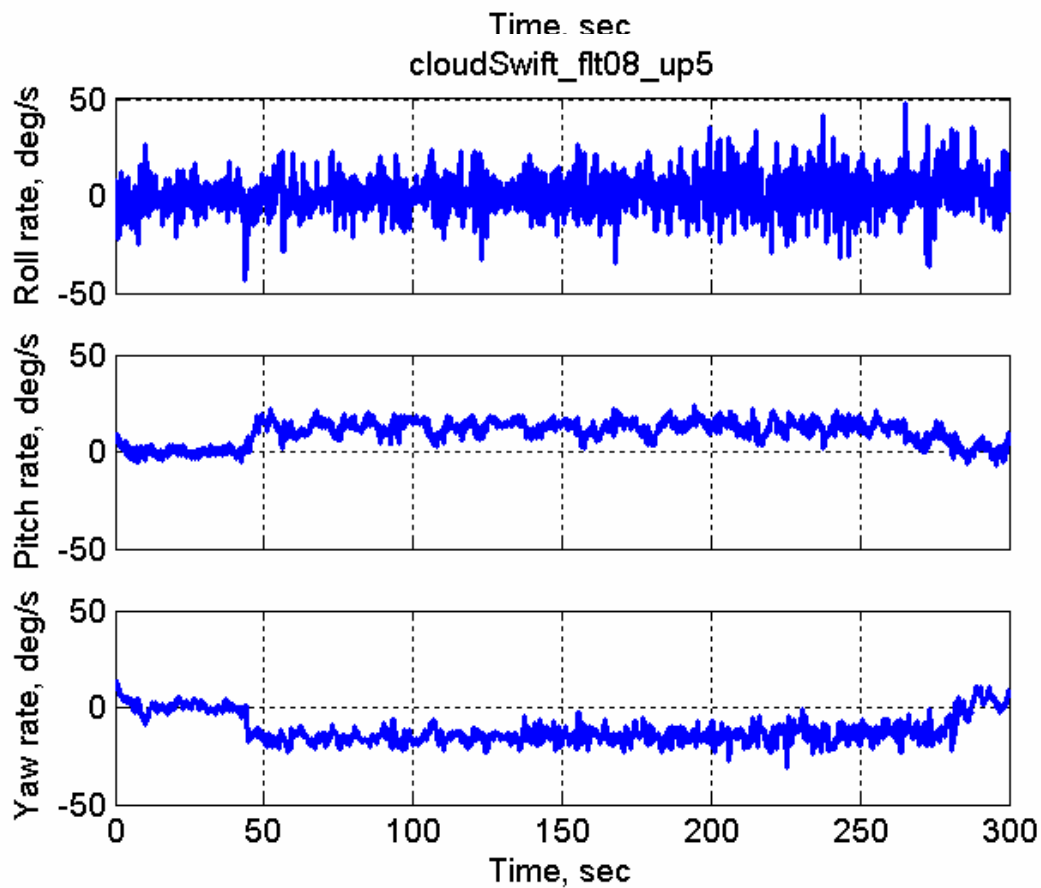
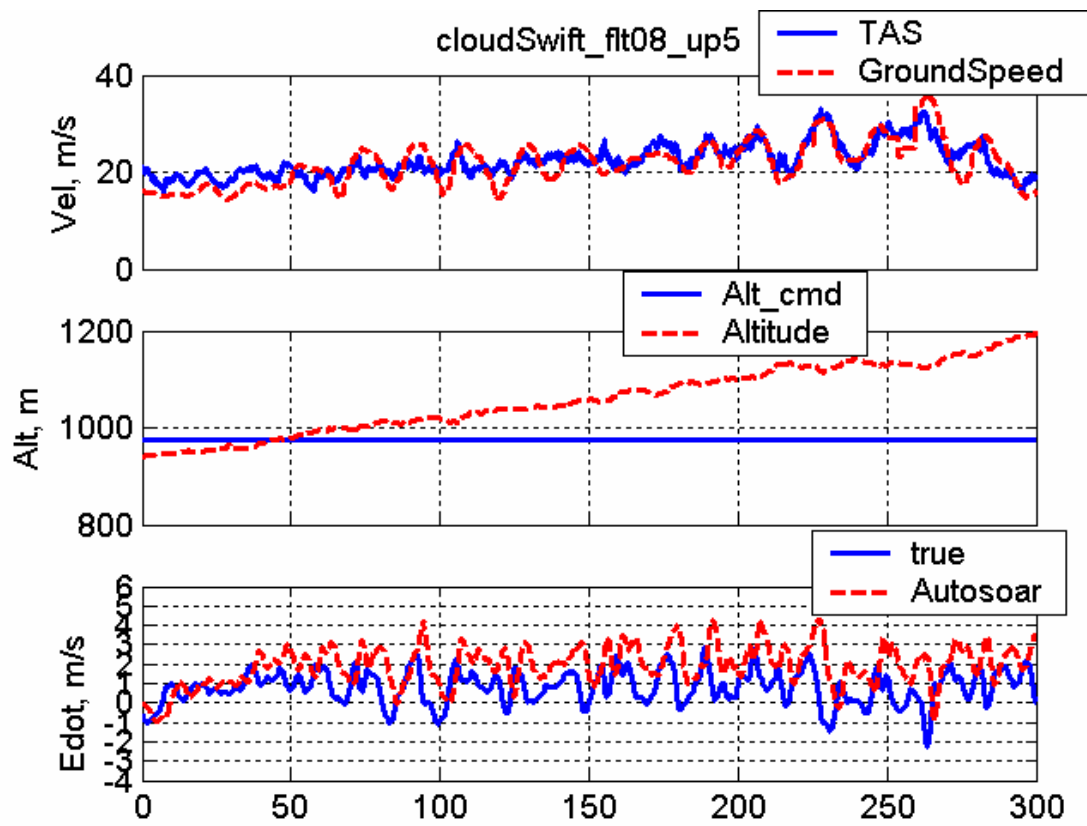


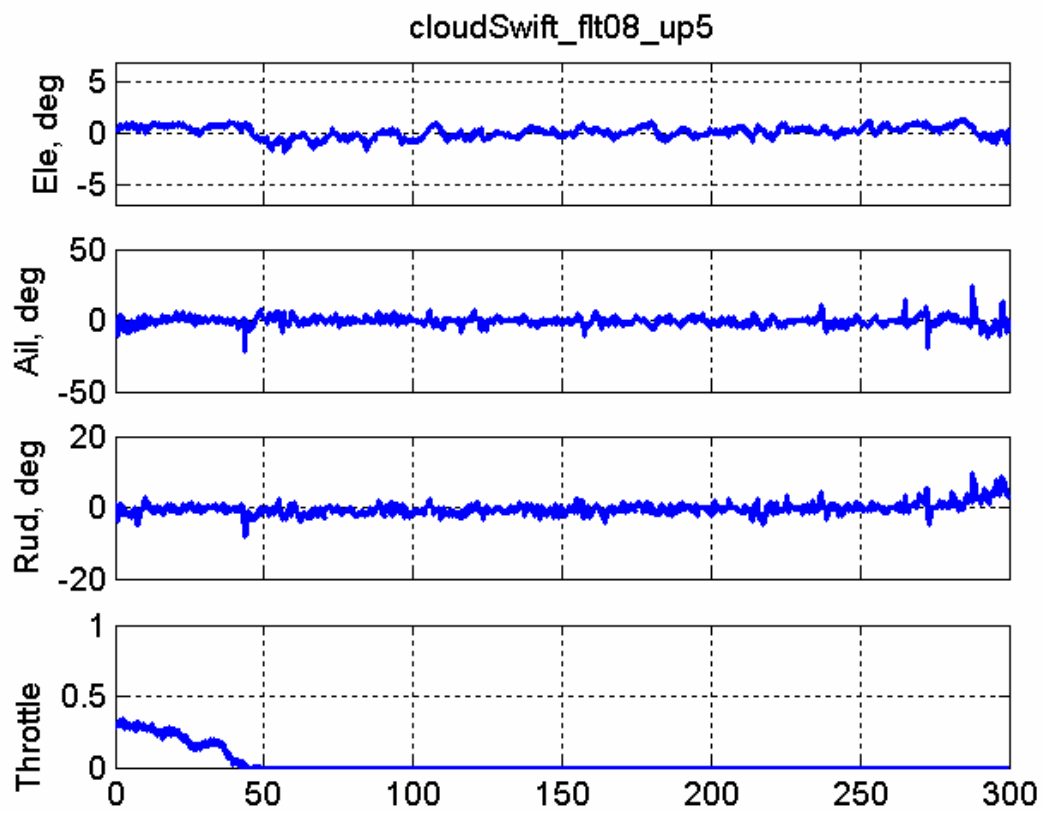
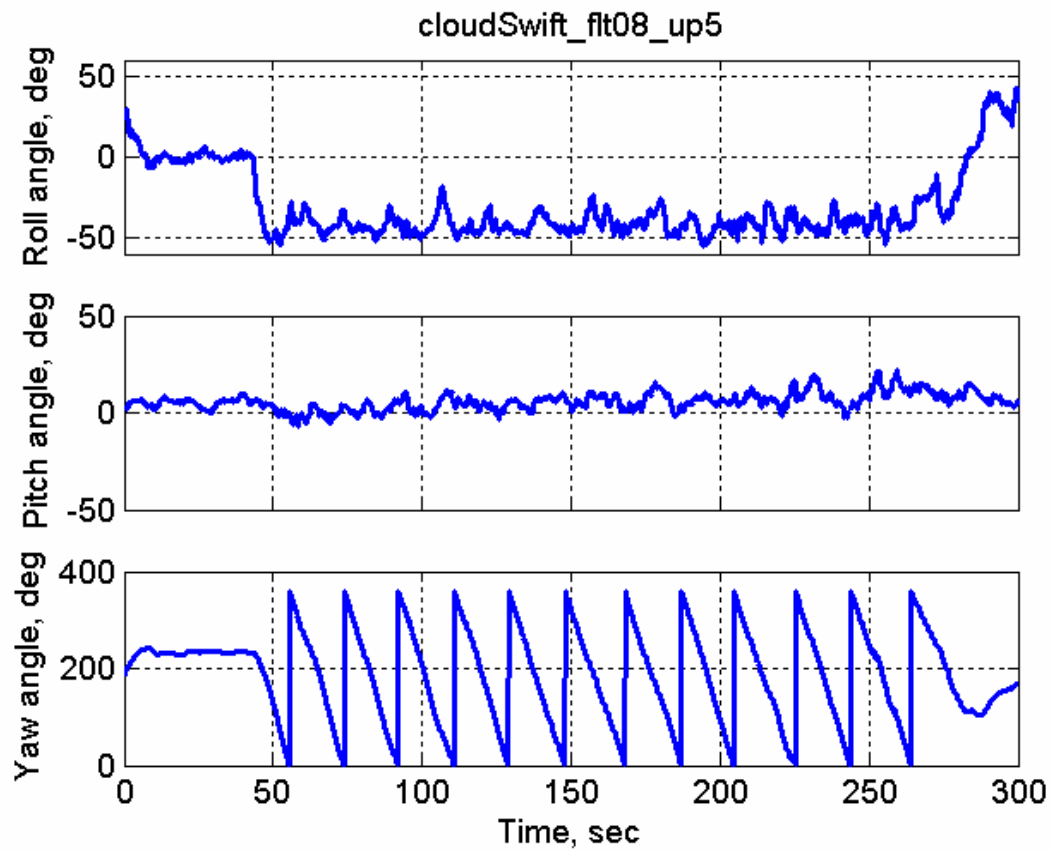
Flight 8, updraft 5

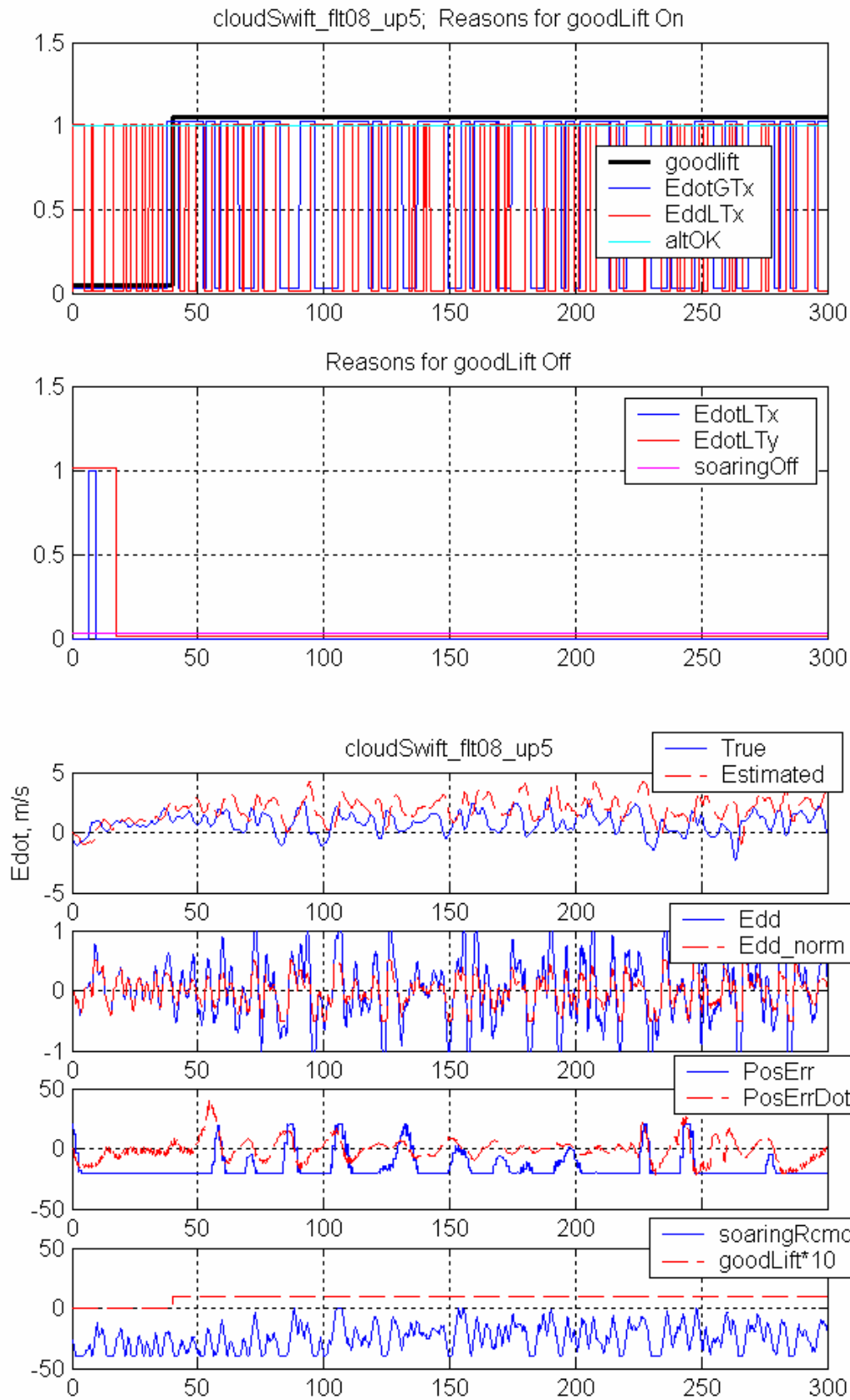
Thermal stops drifting. Also may have had gps sat changes.





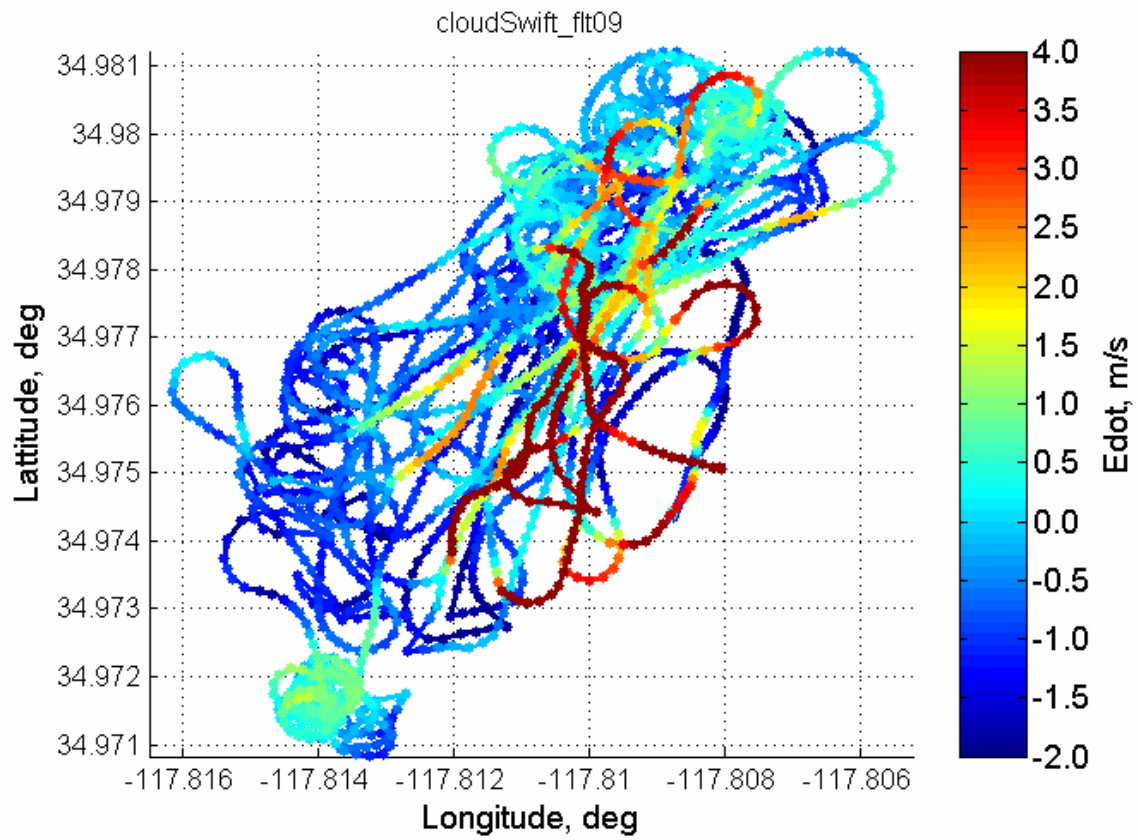


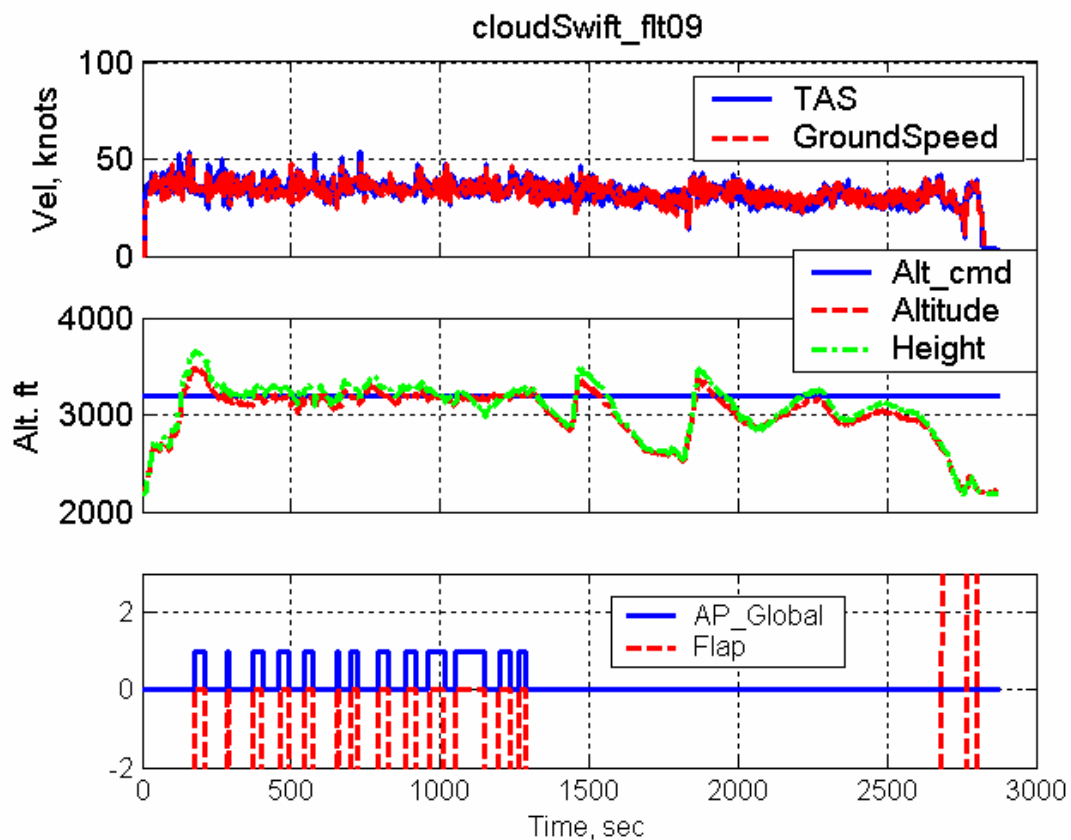
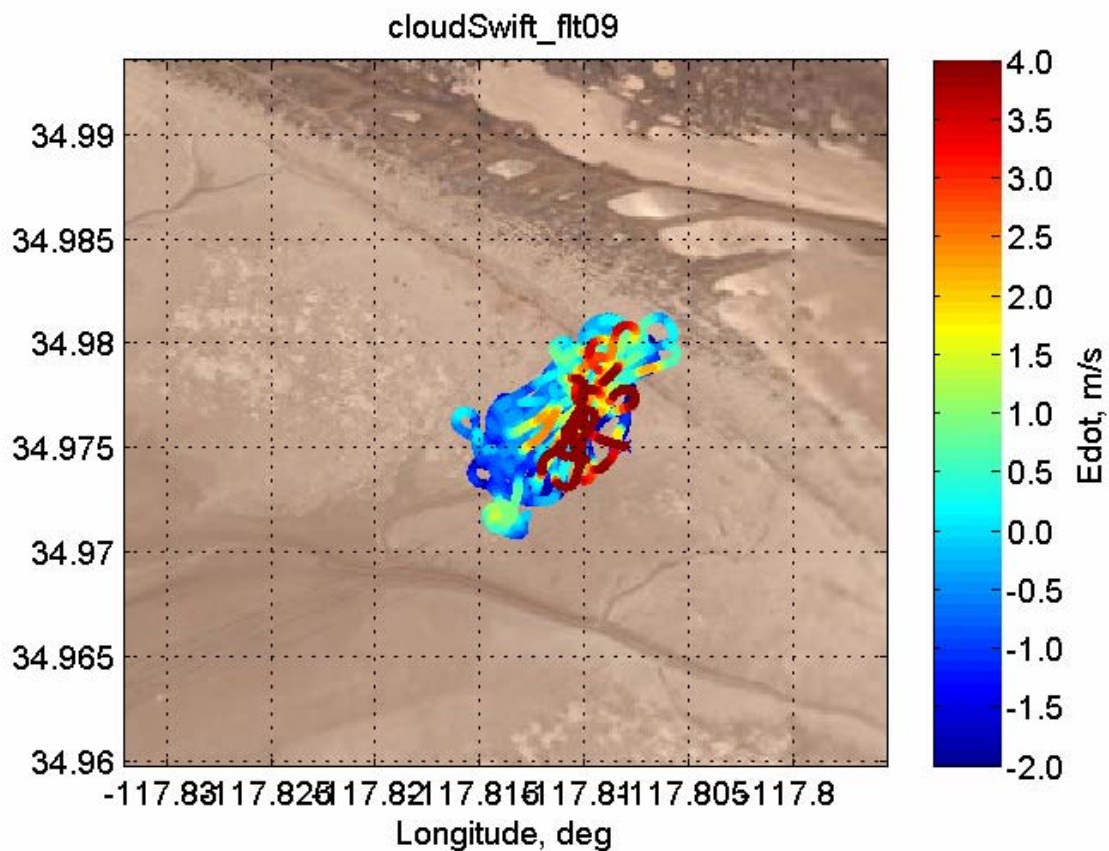


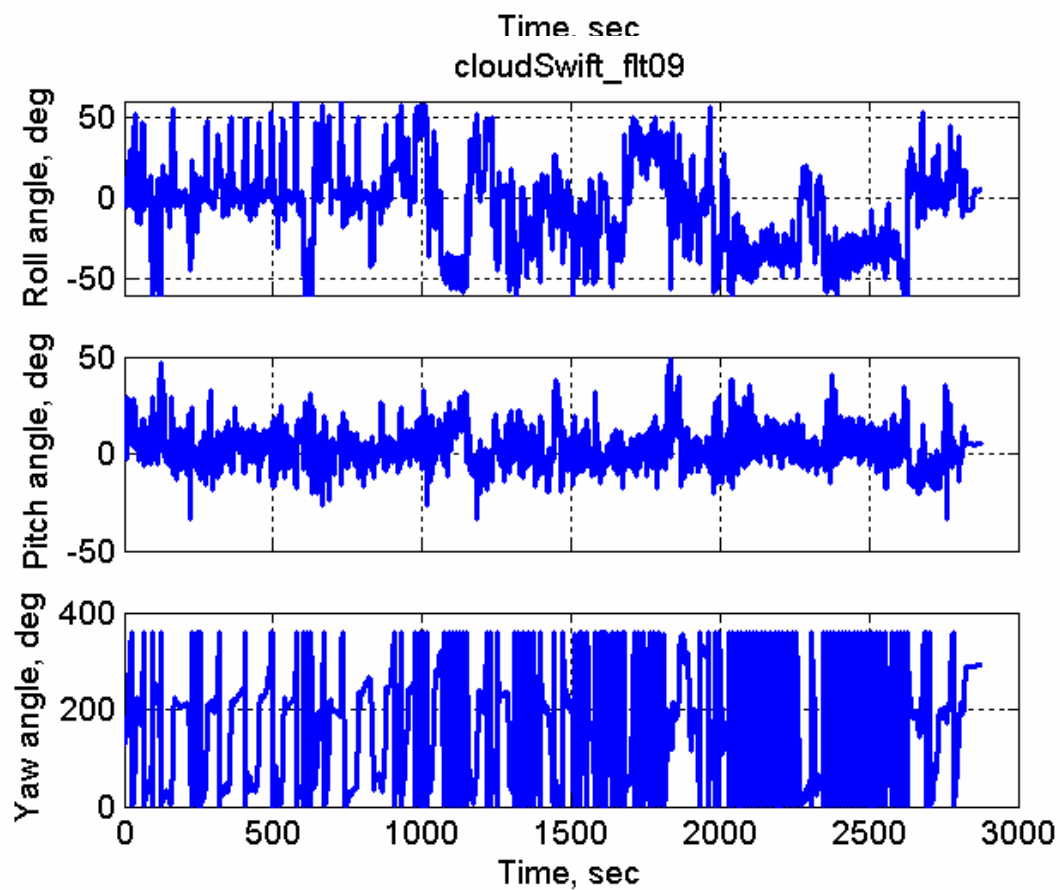
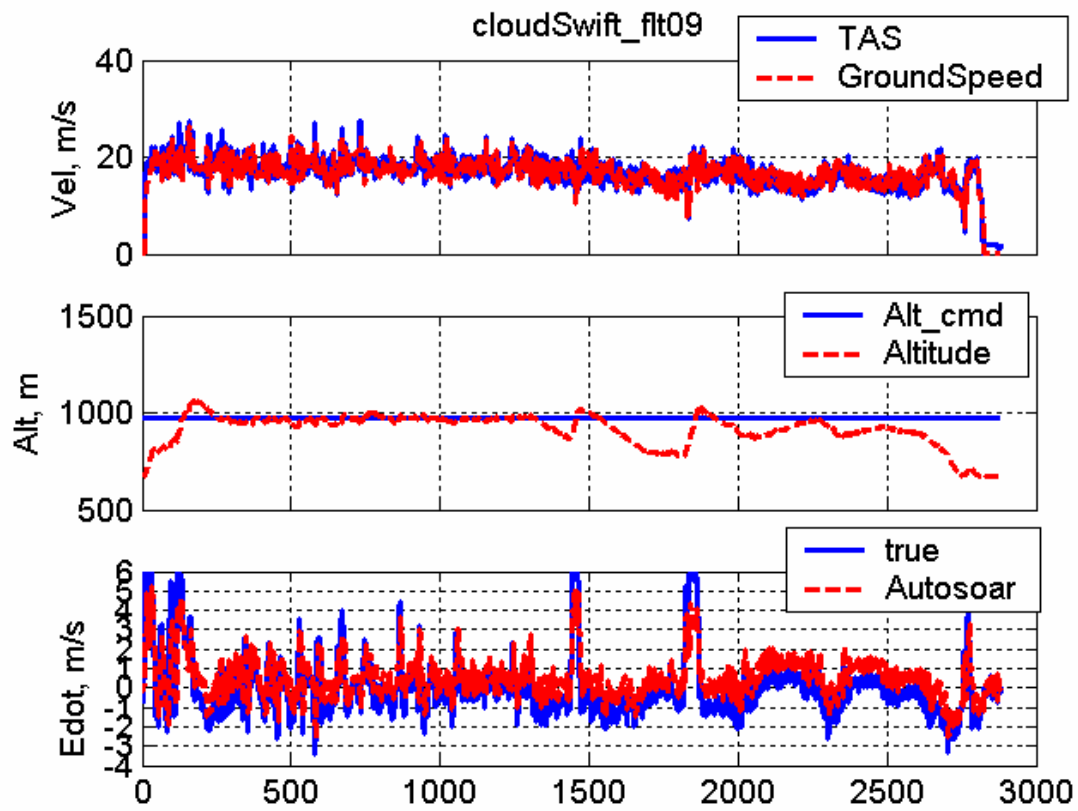


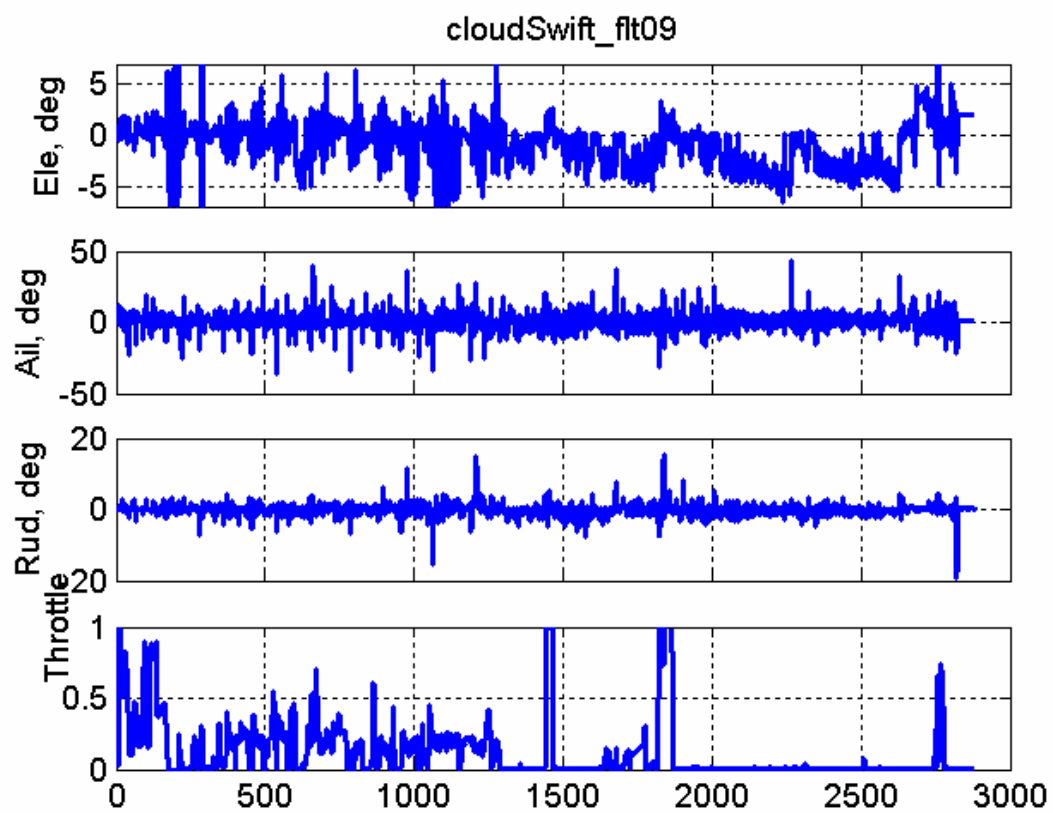
Flight 9

Flight 9 was used to tune the velocity autopilot gains.

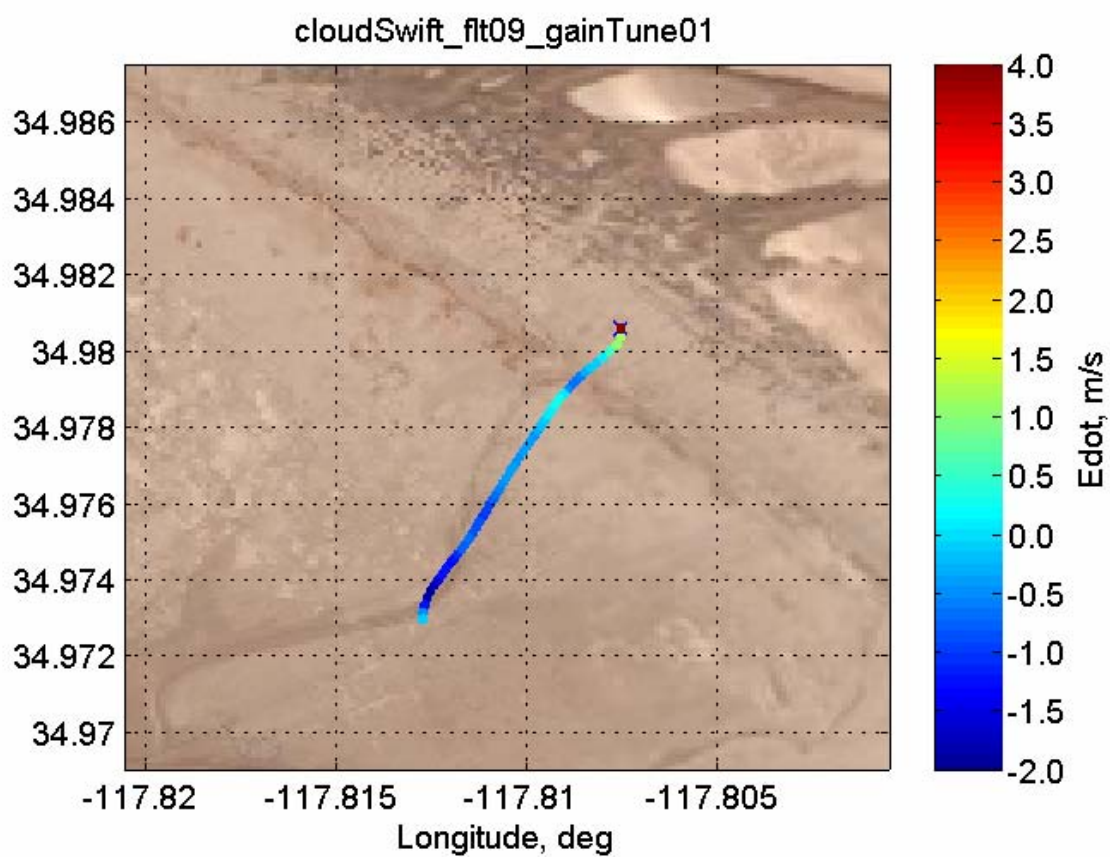


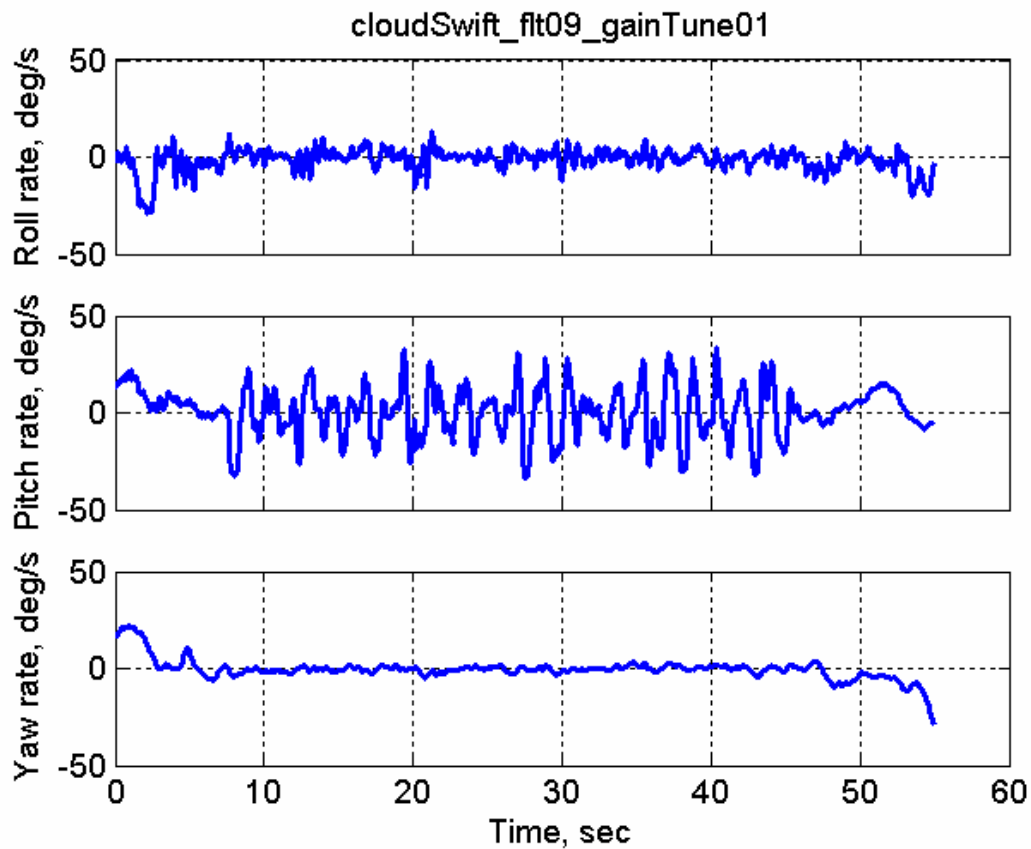
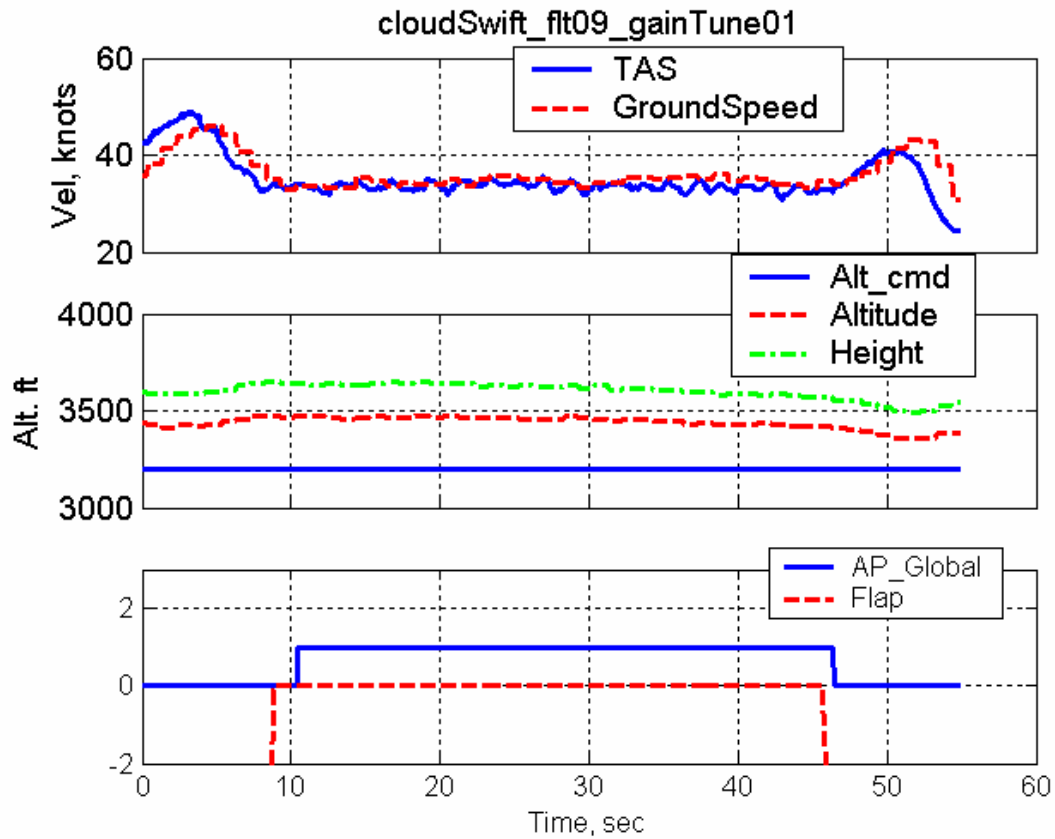


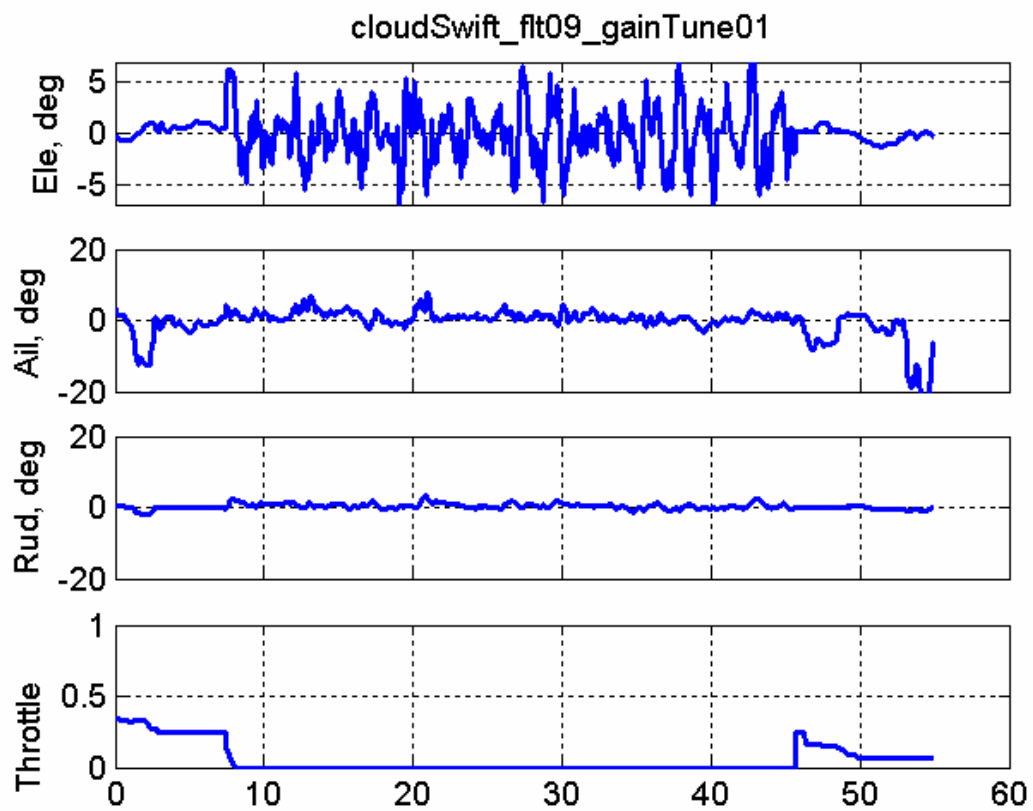
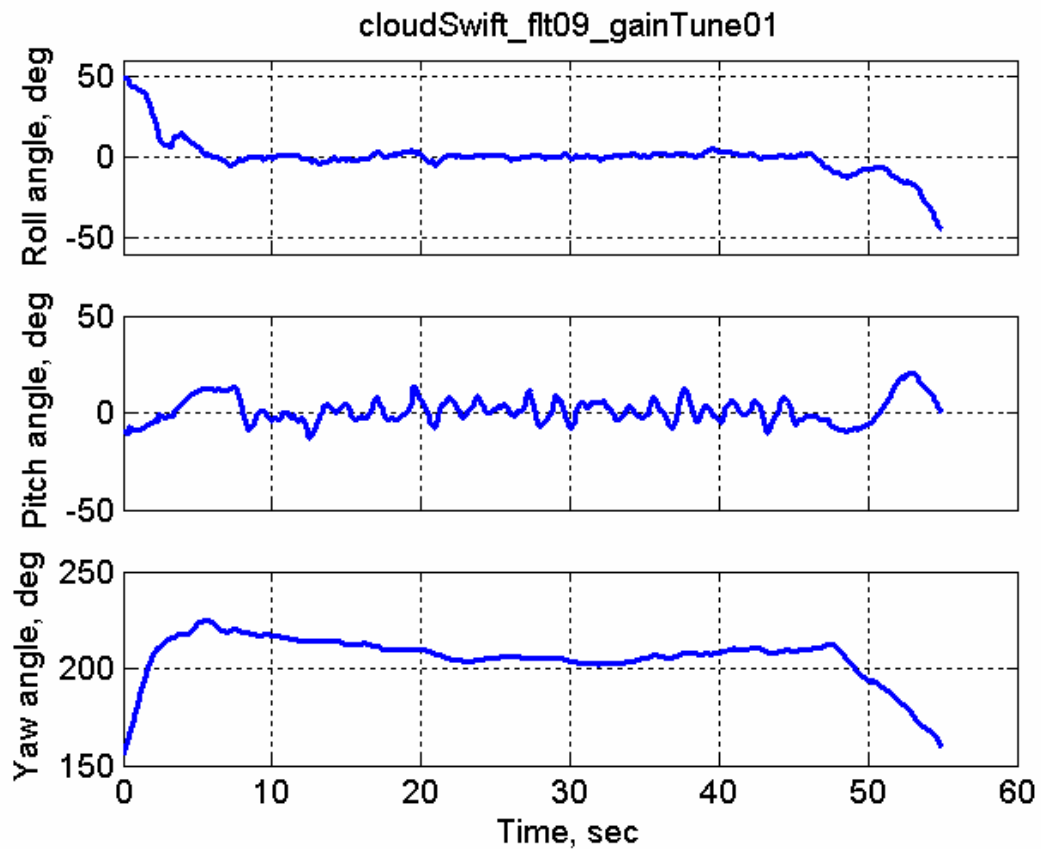




Flight 9, gain tune 1

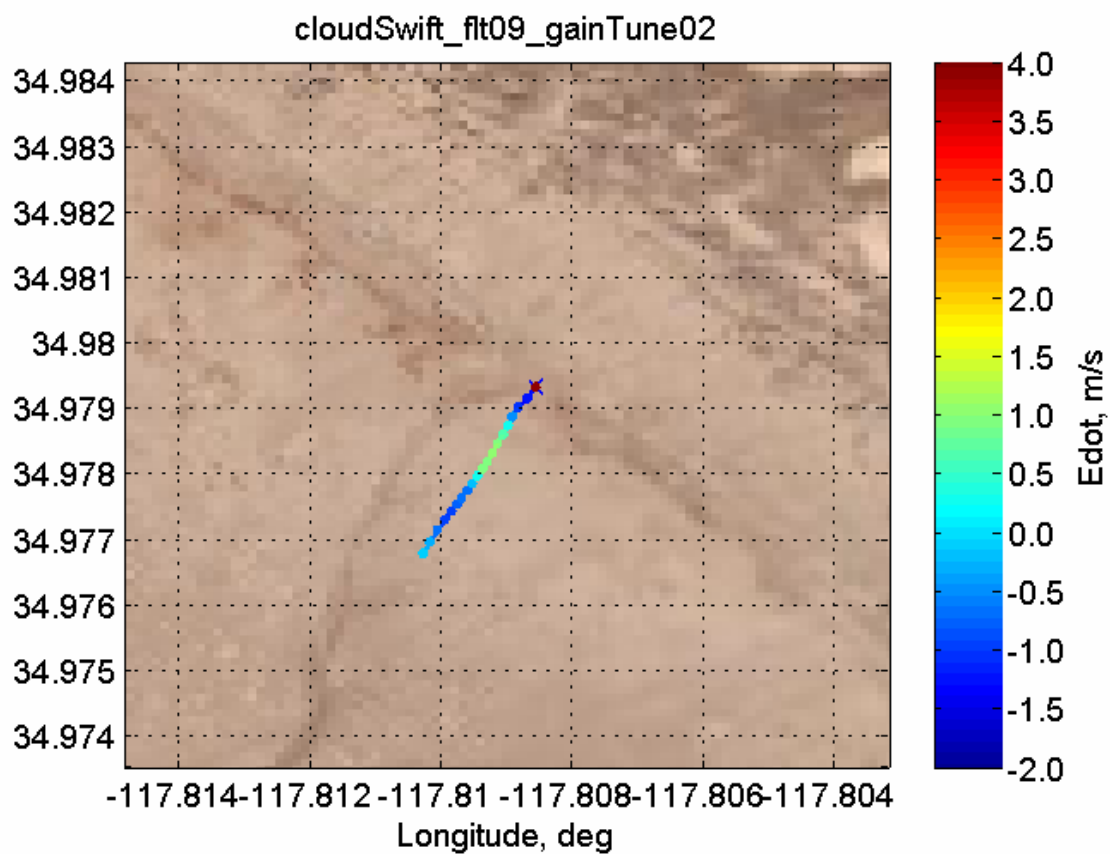


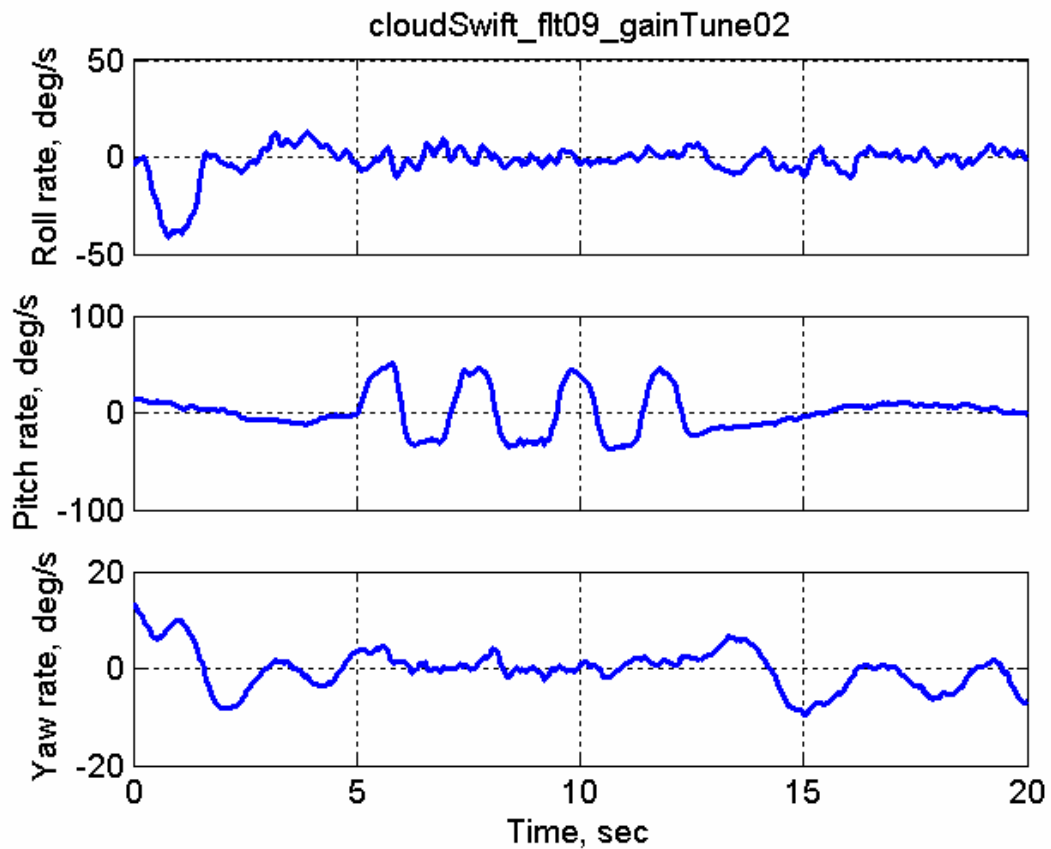
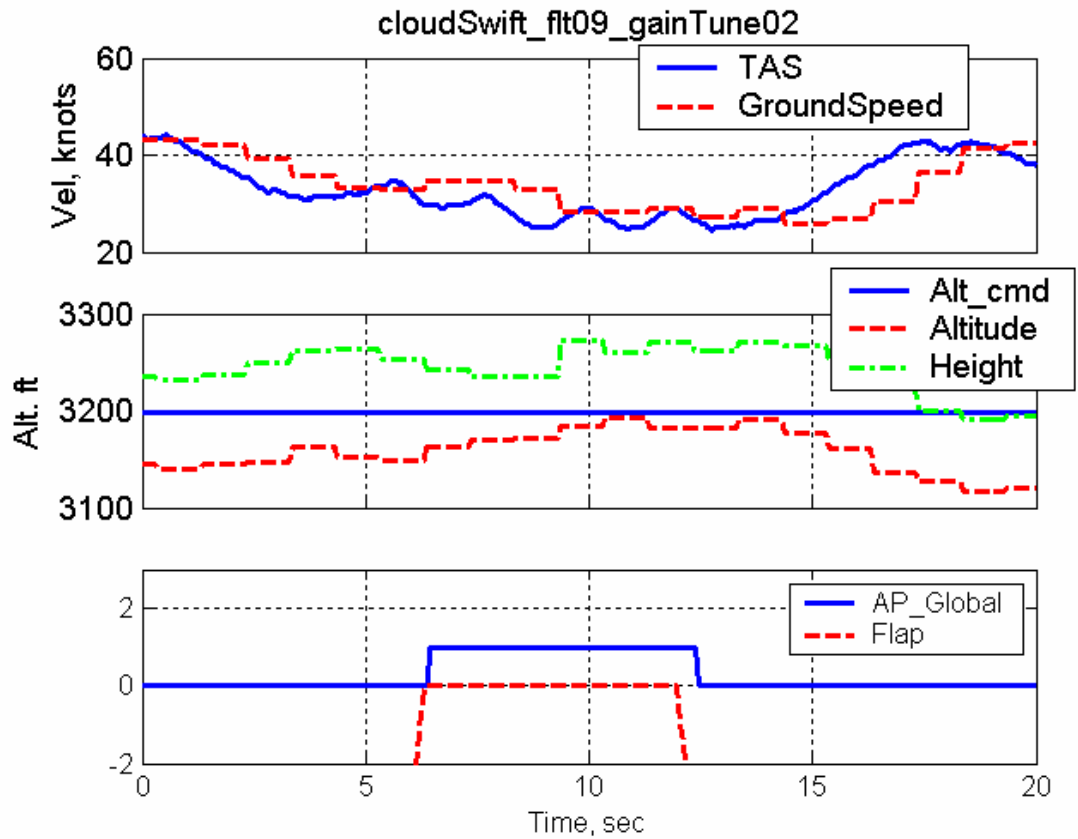


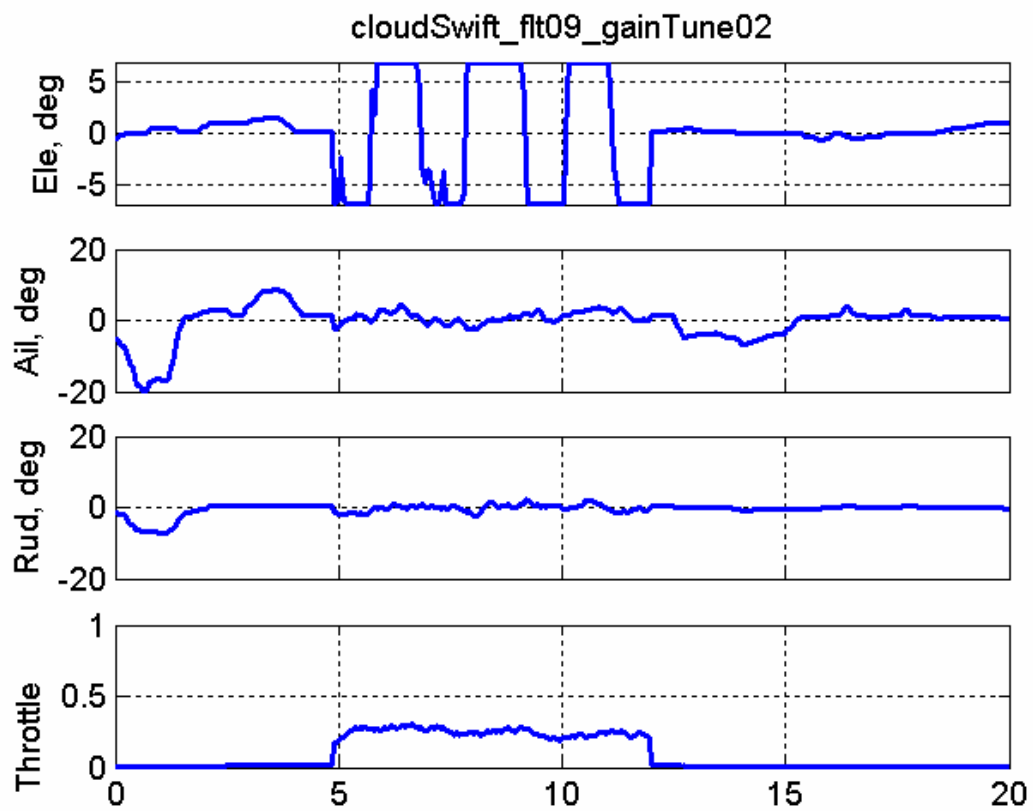
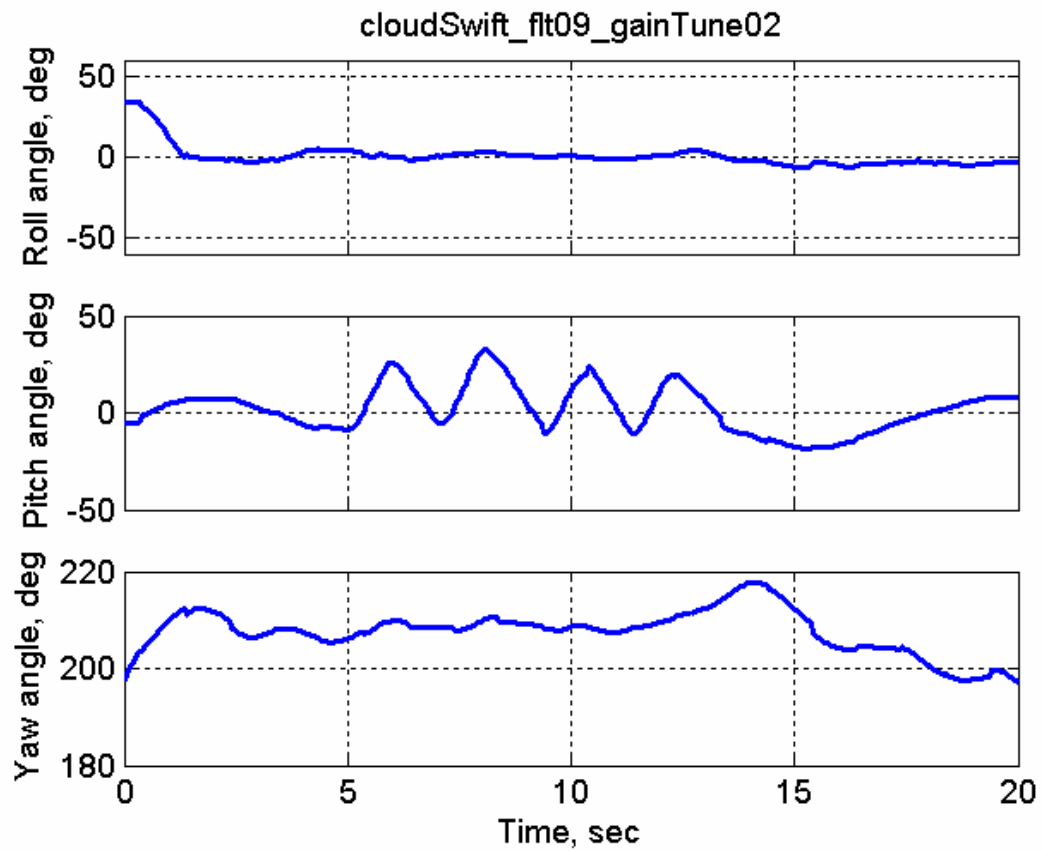


Flight 9, gain tune 2

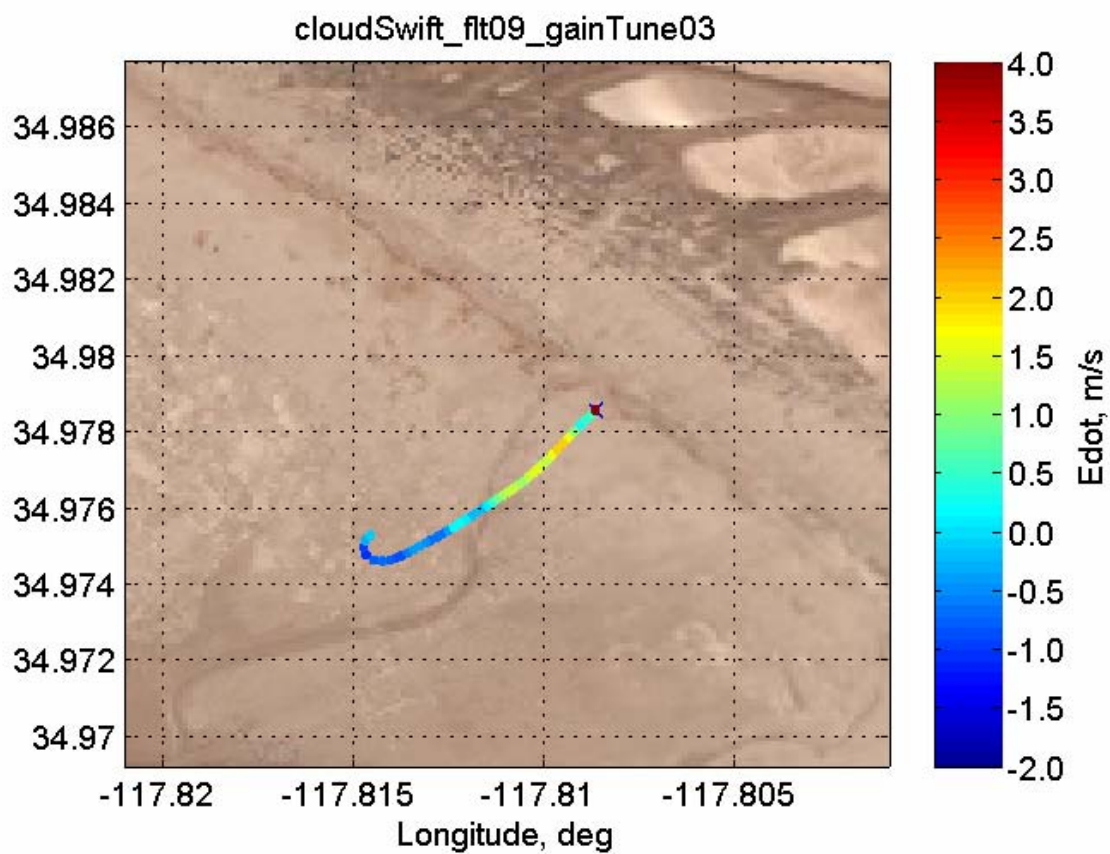
Wild ride.

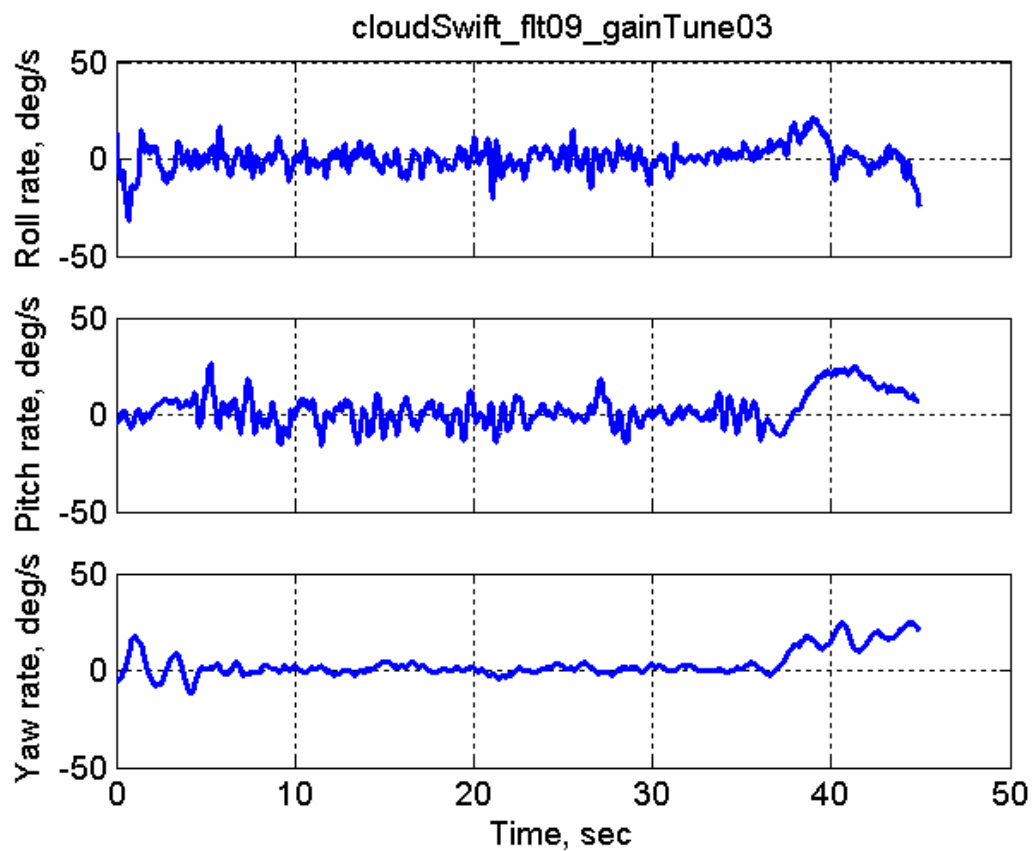
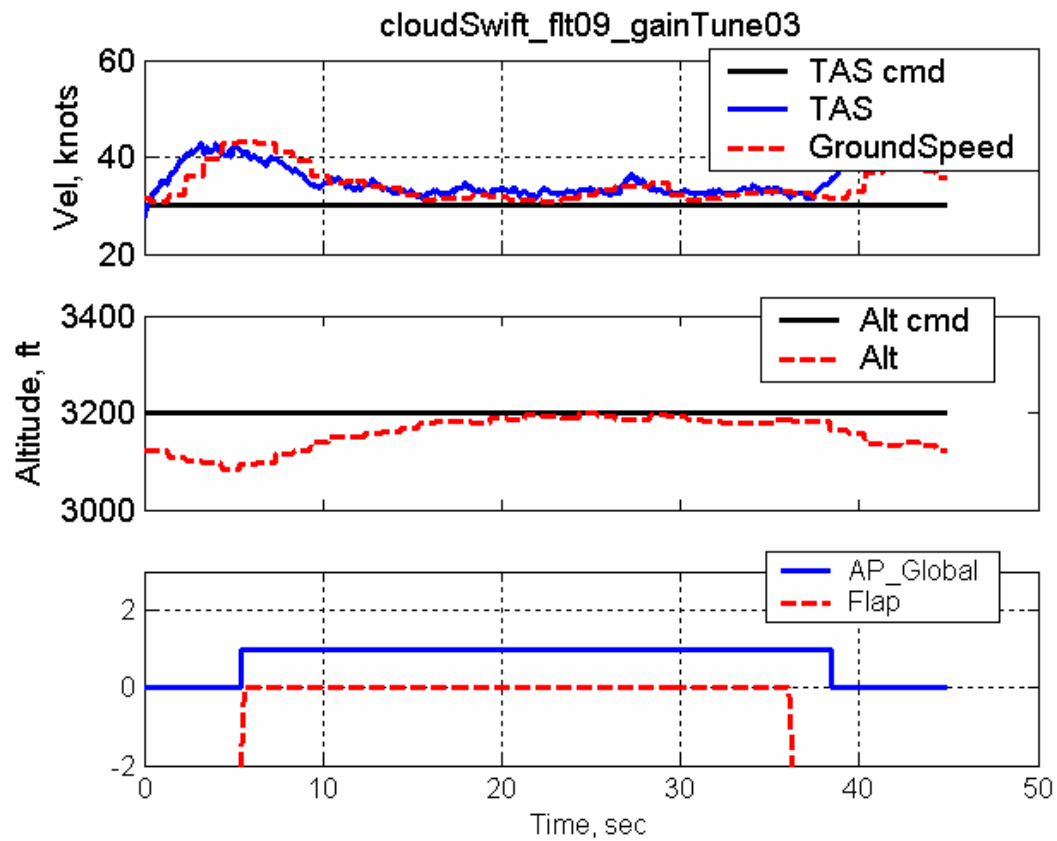


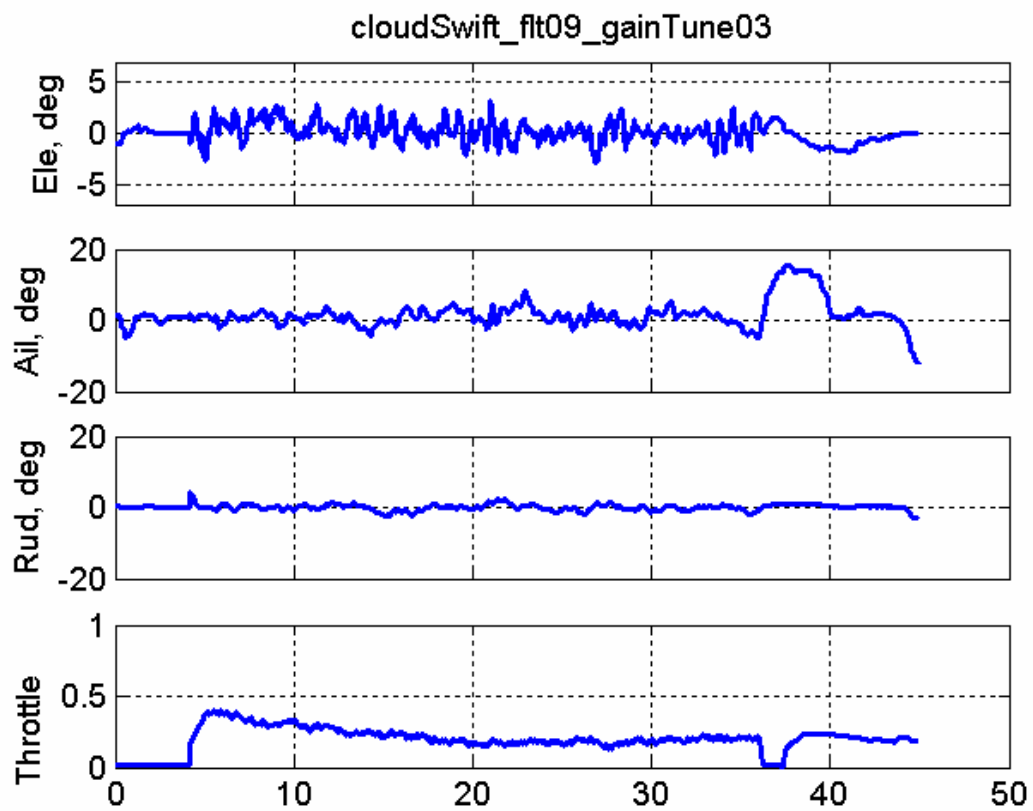
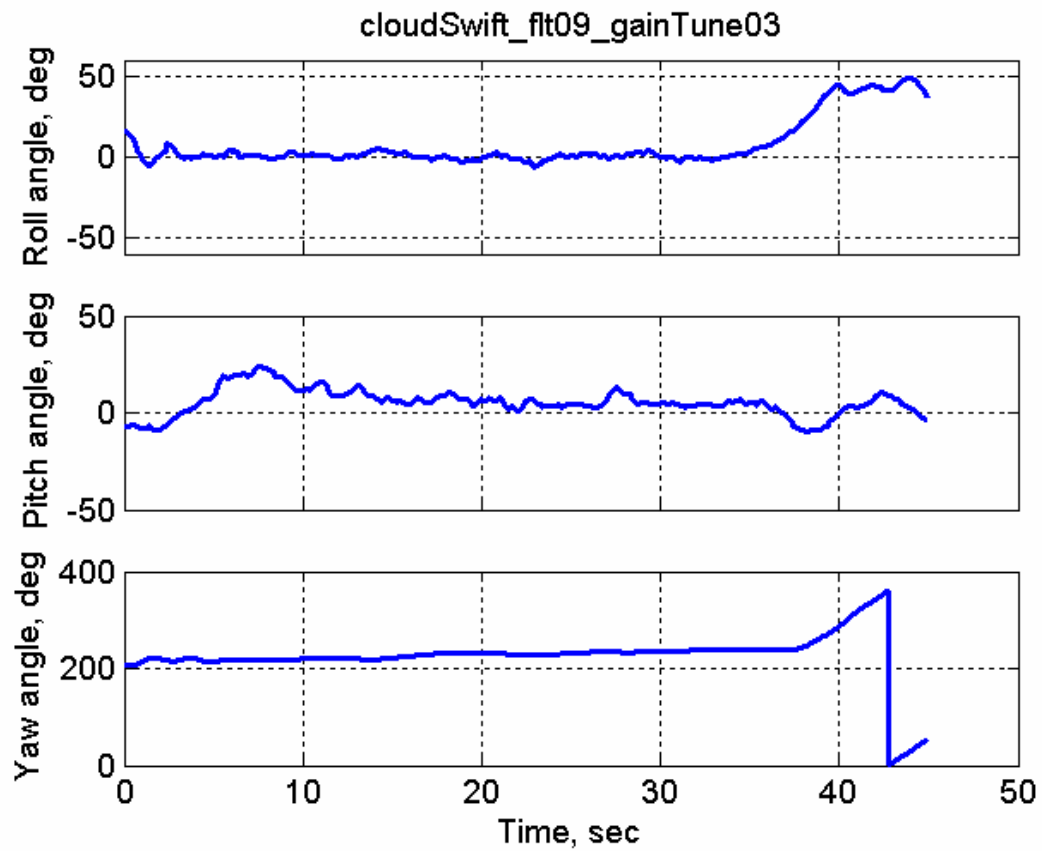




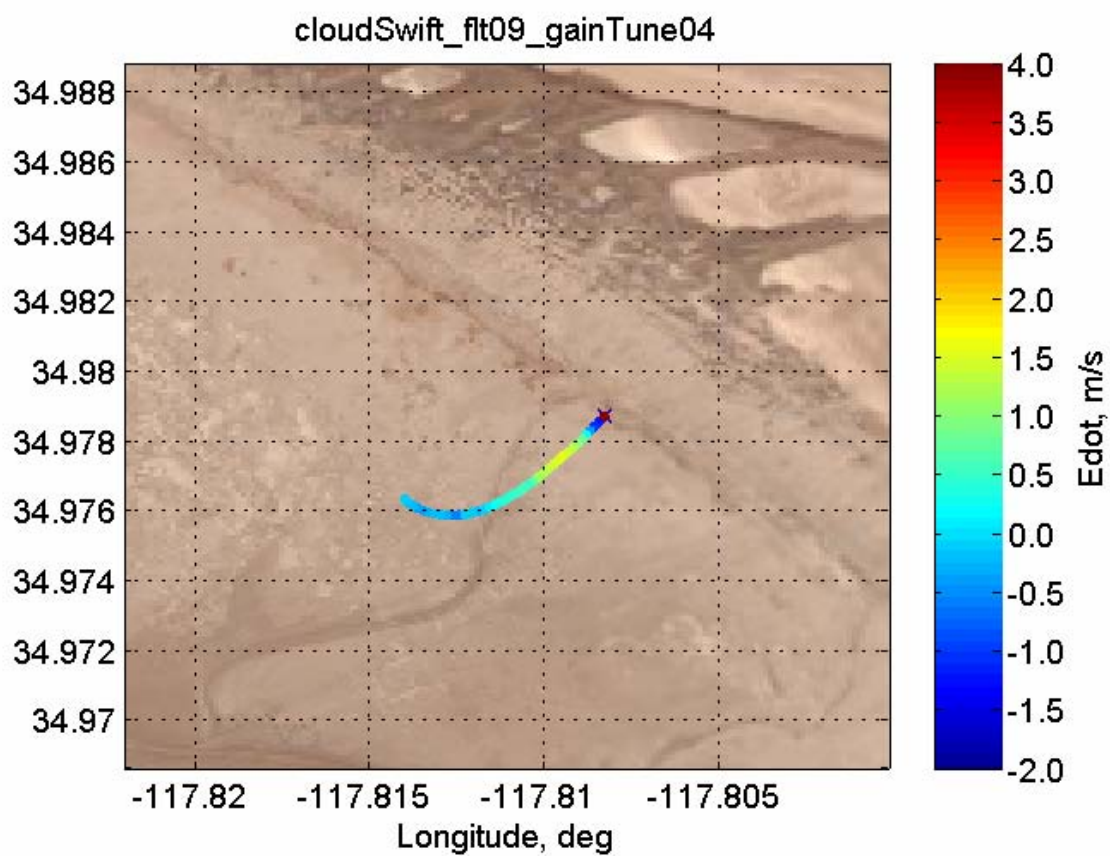
Flight 9, gain tune 3

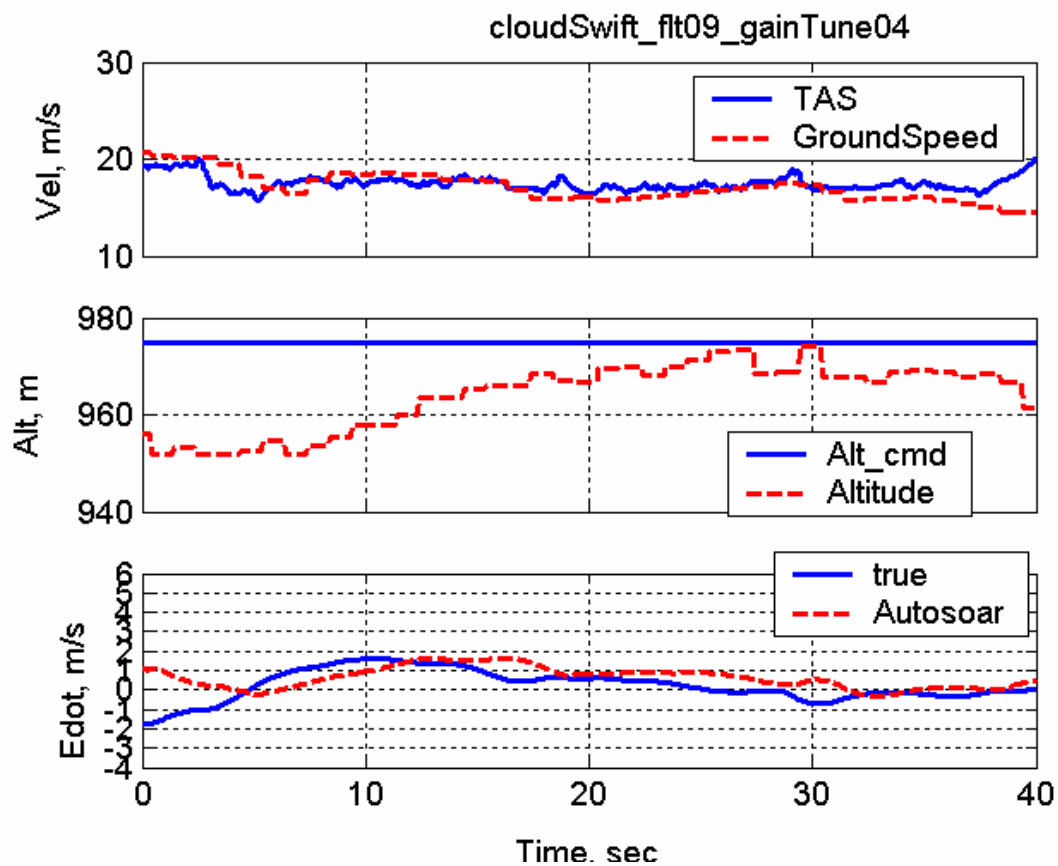
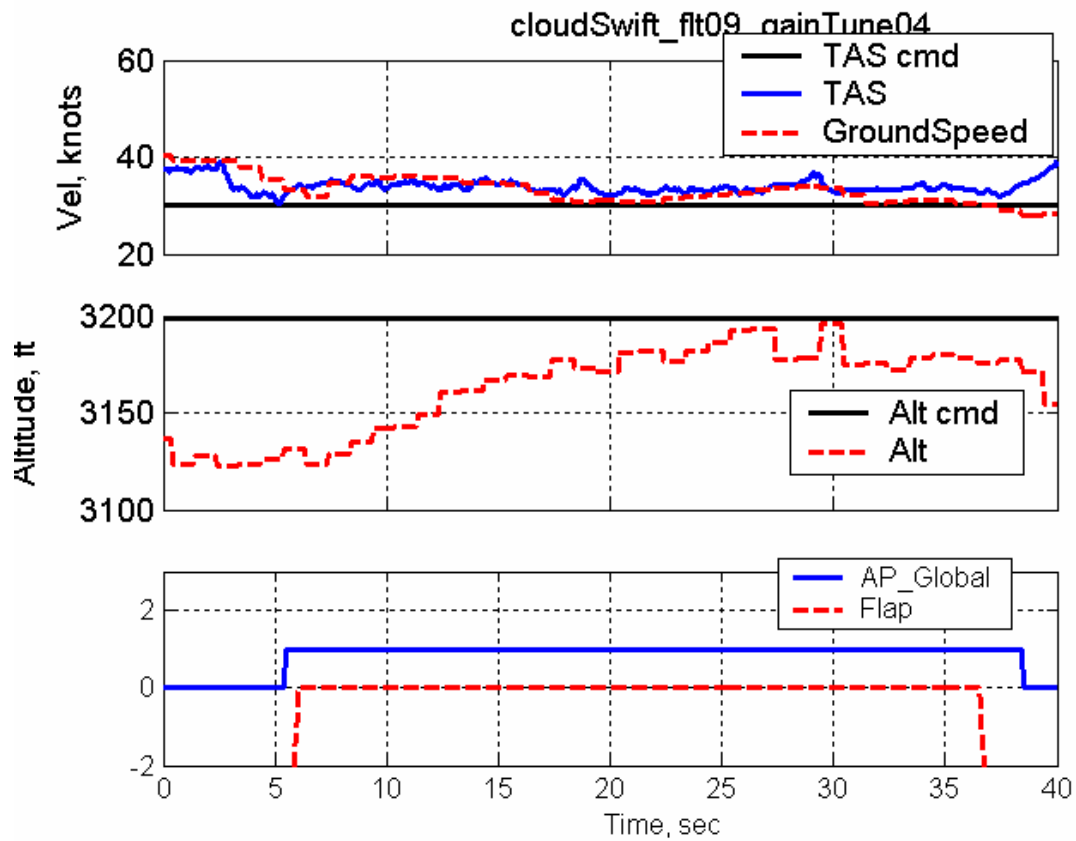


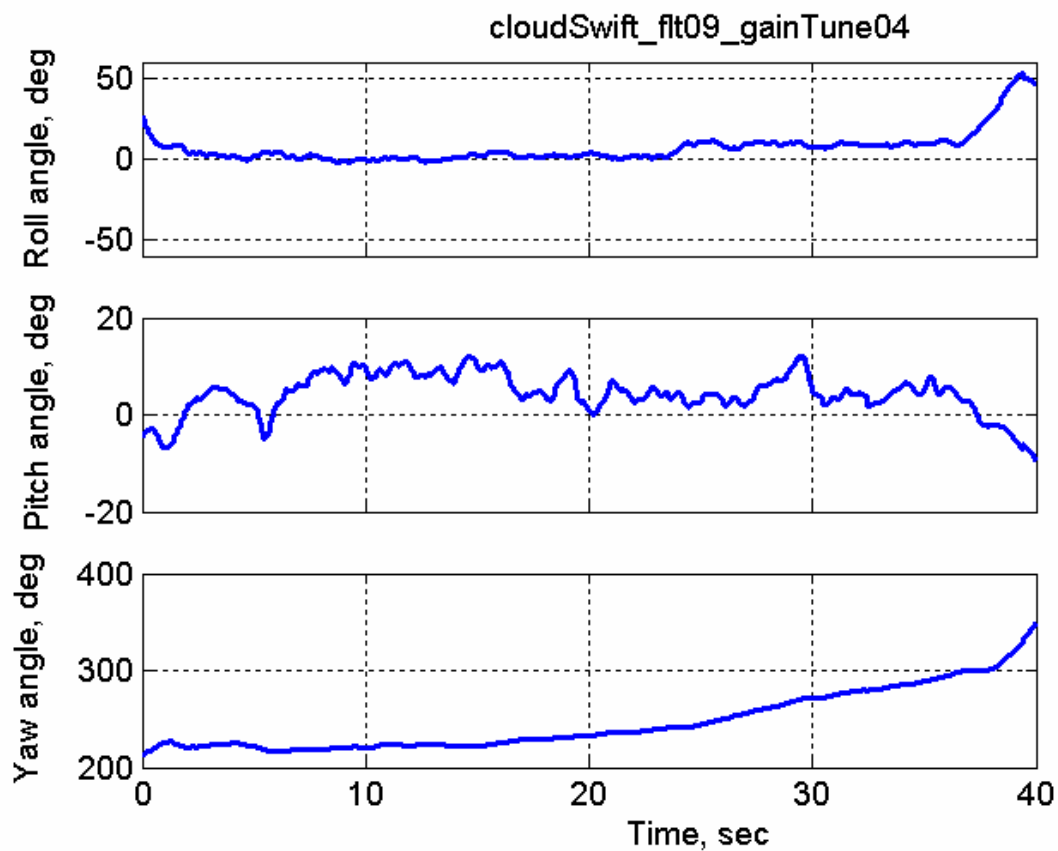
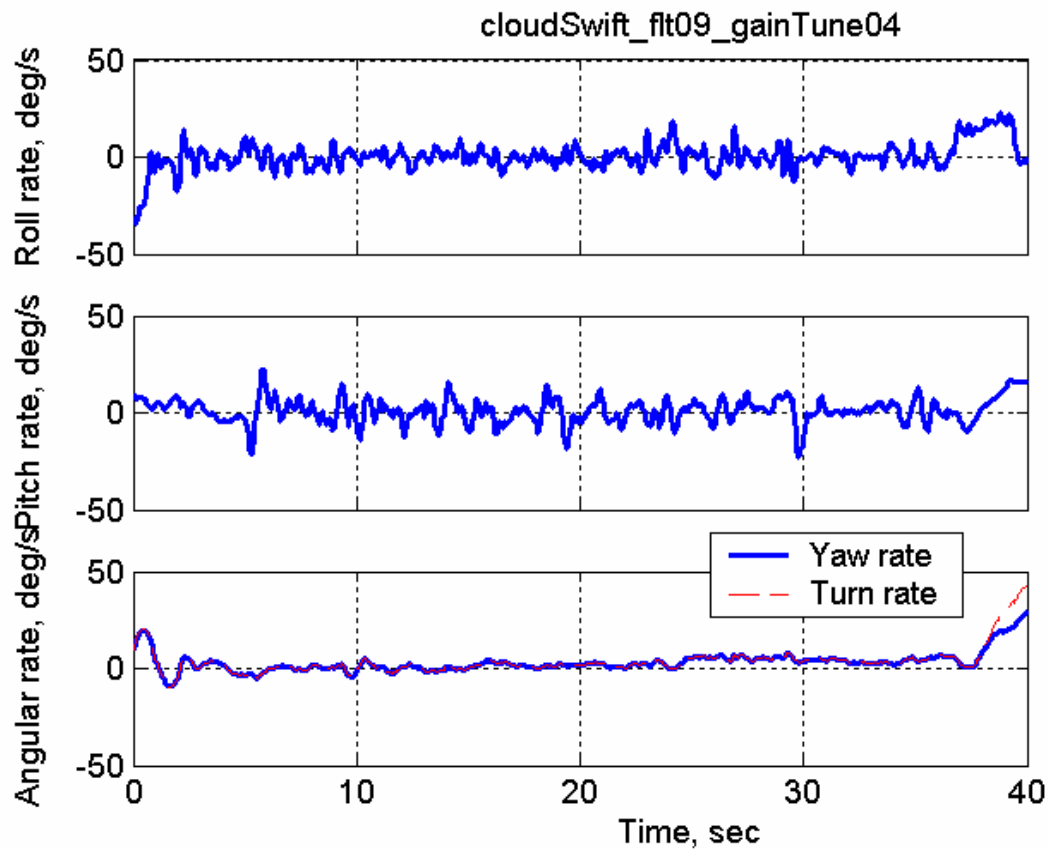




Flight 9, gain tune 4

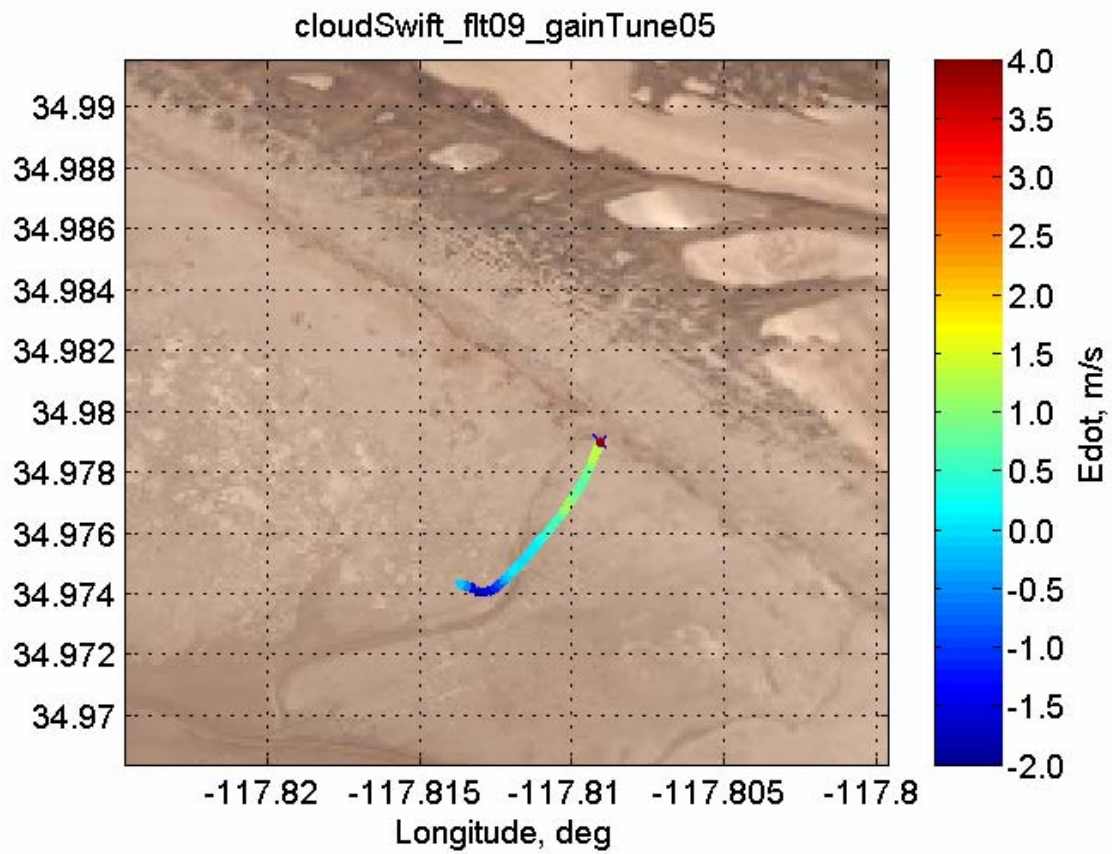


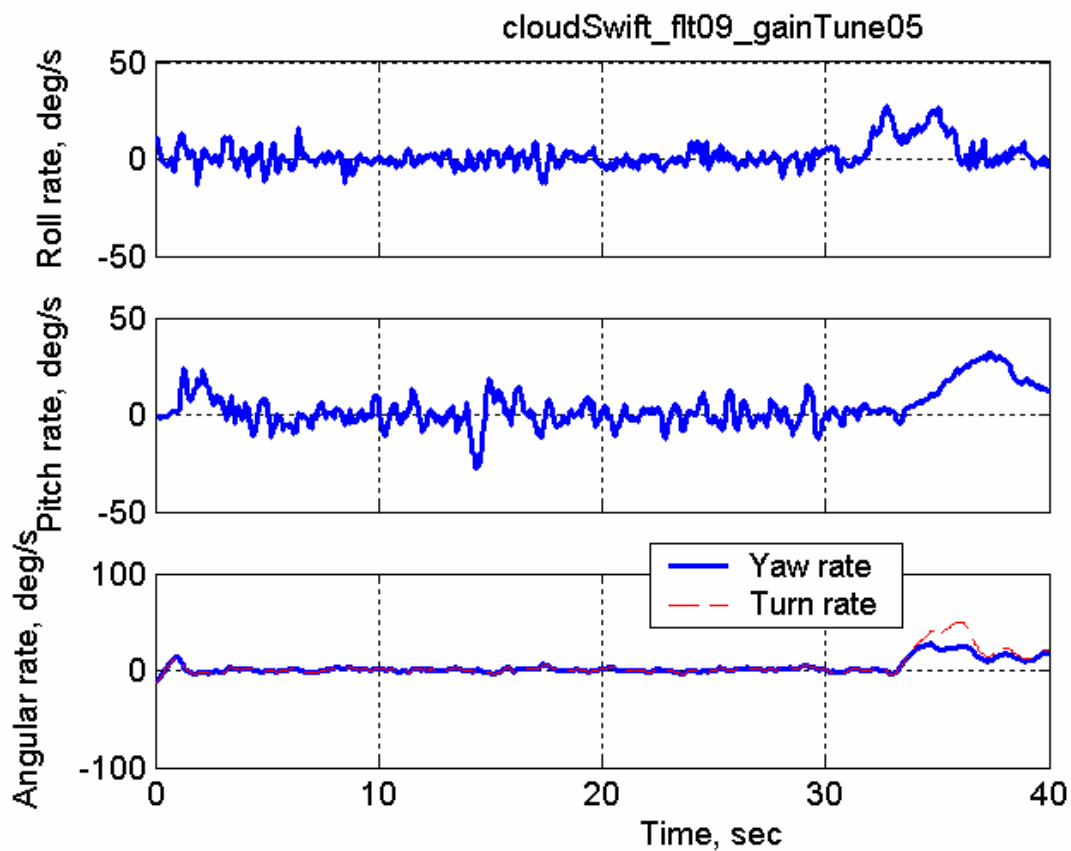
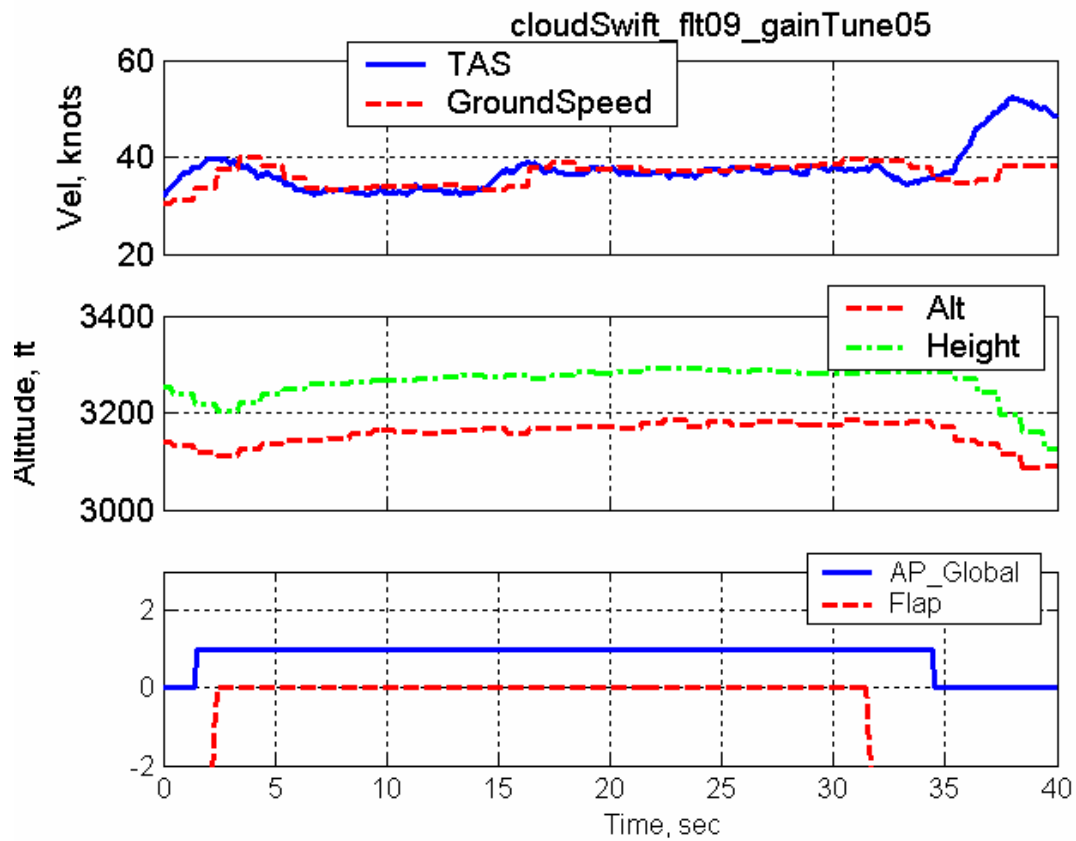


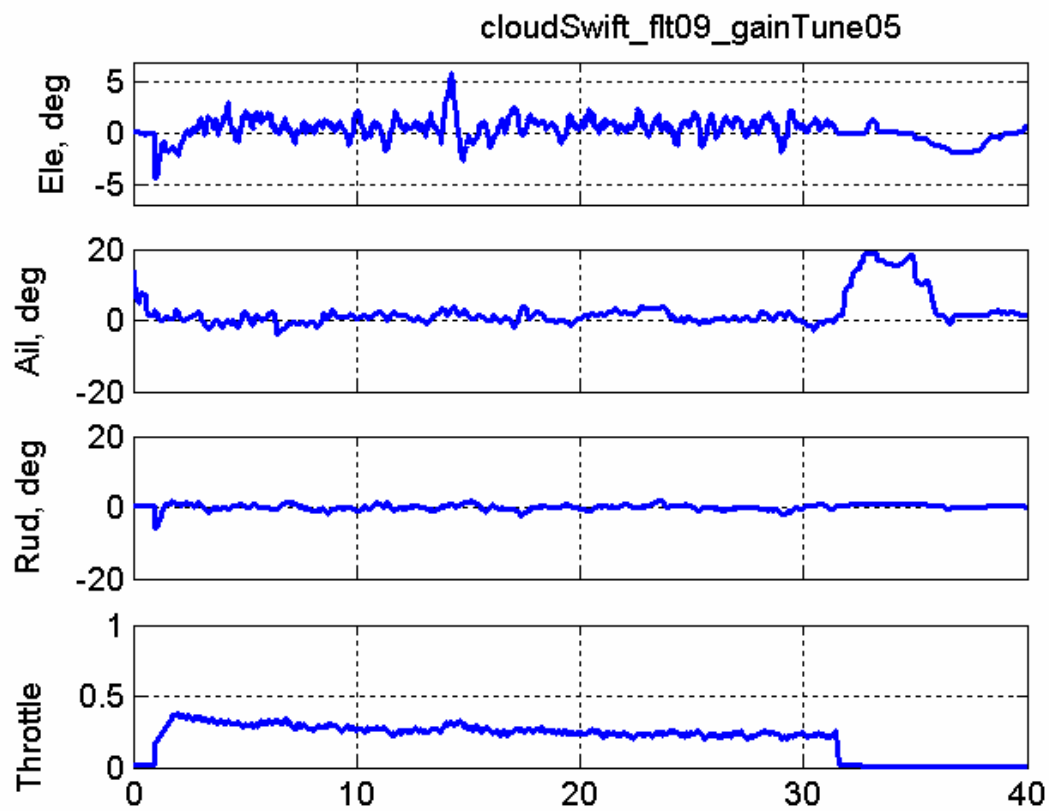
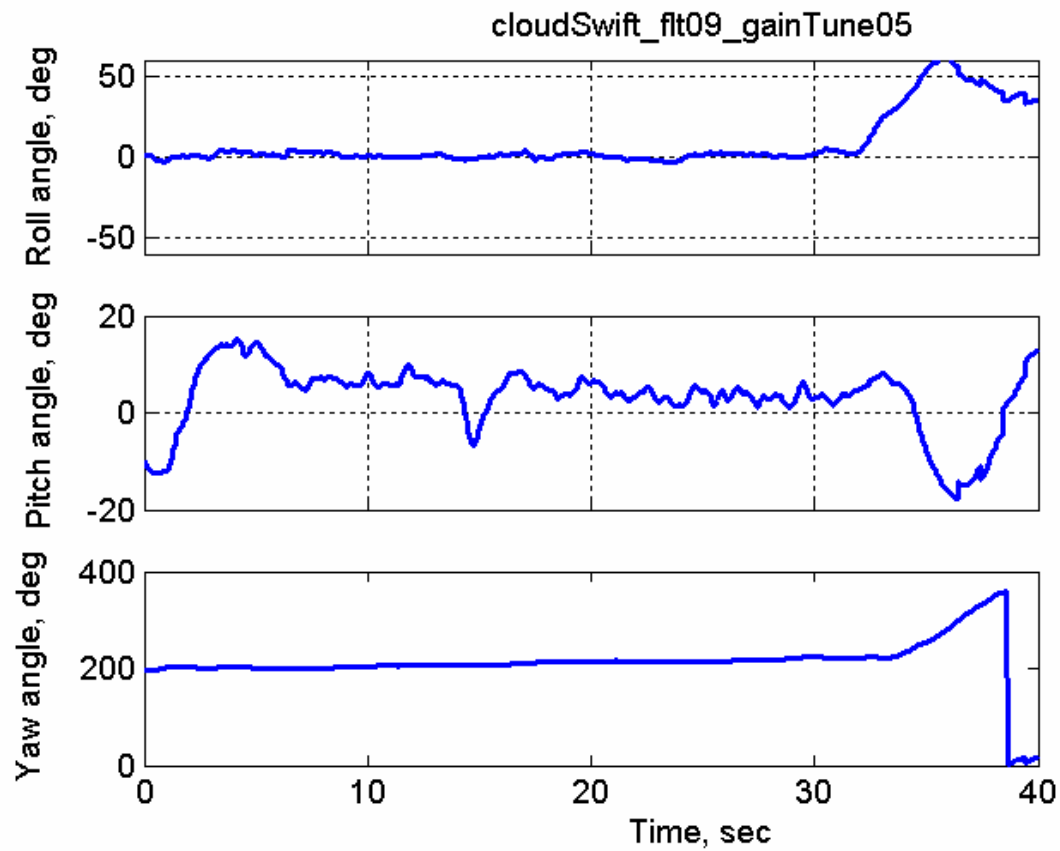




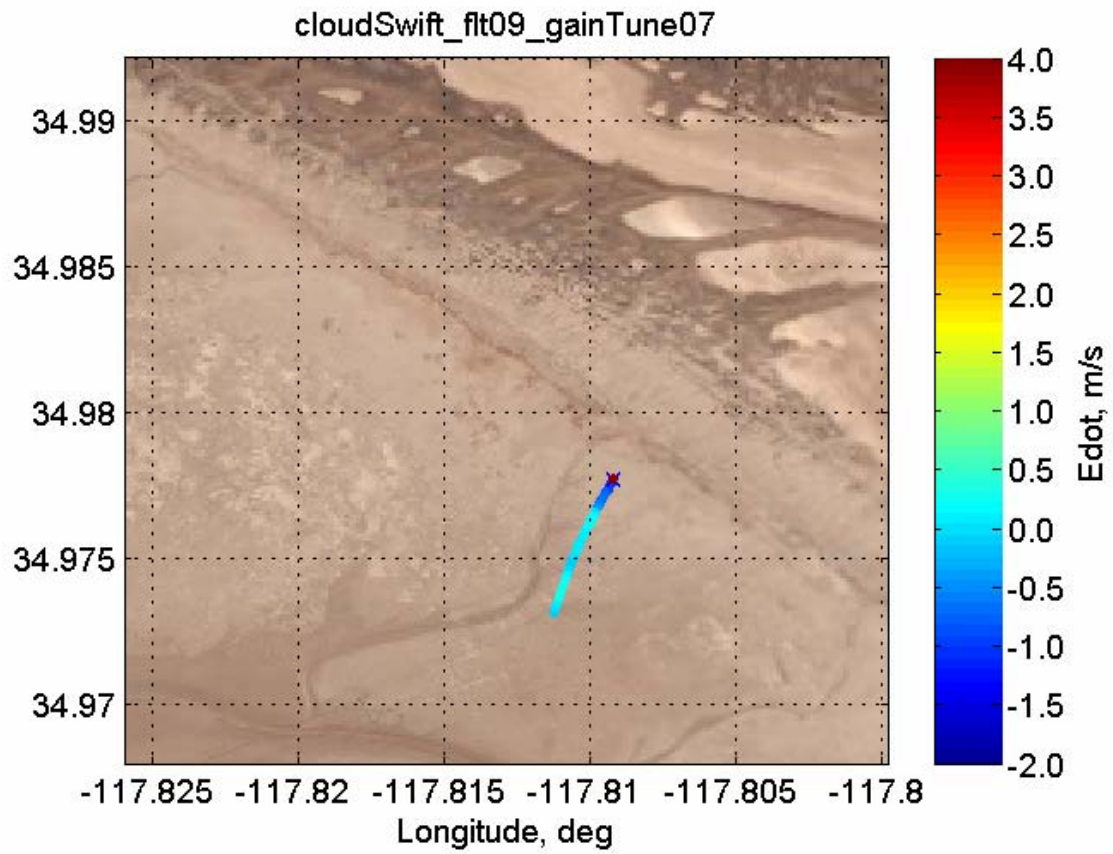
Flight 9, gain tune 5

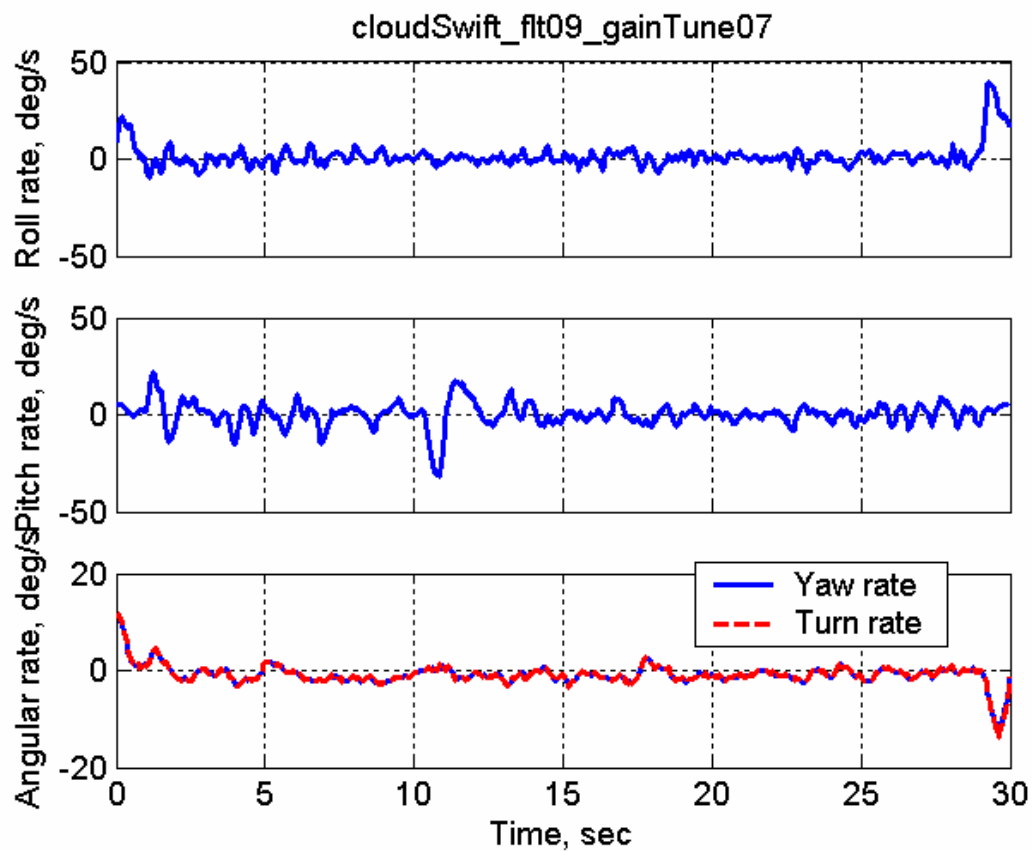
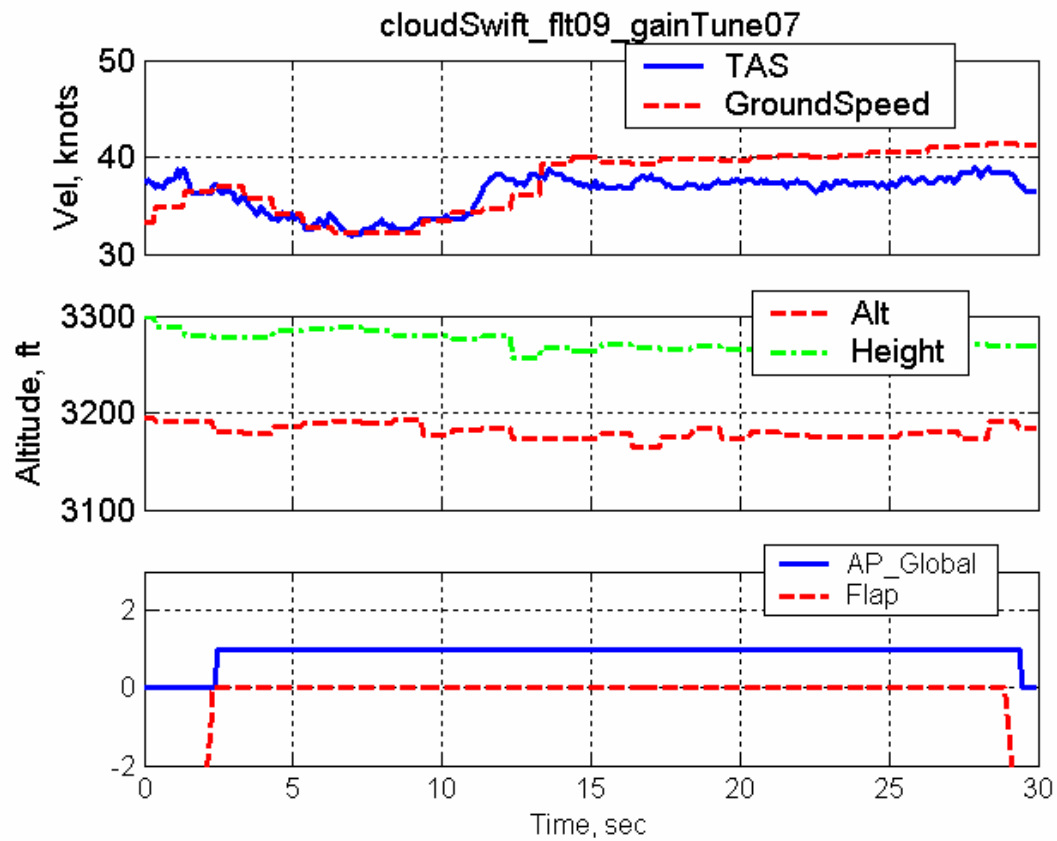


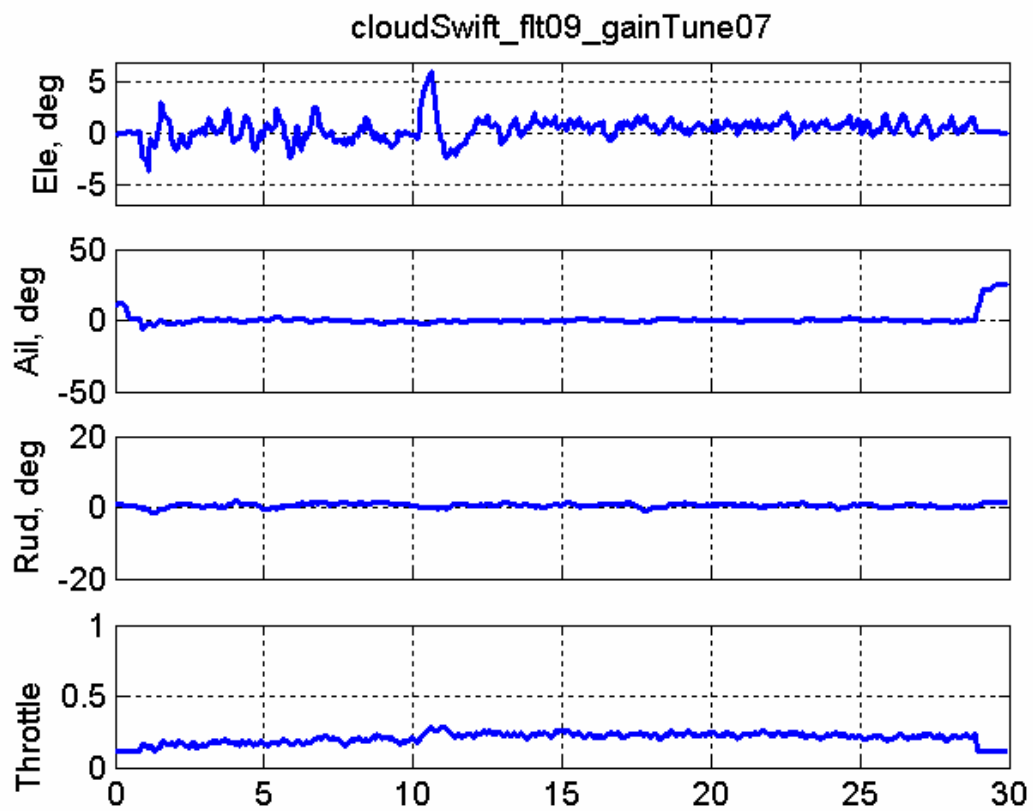
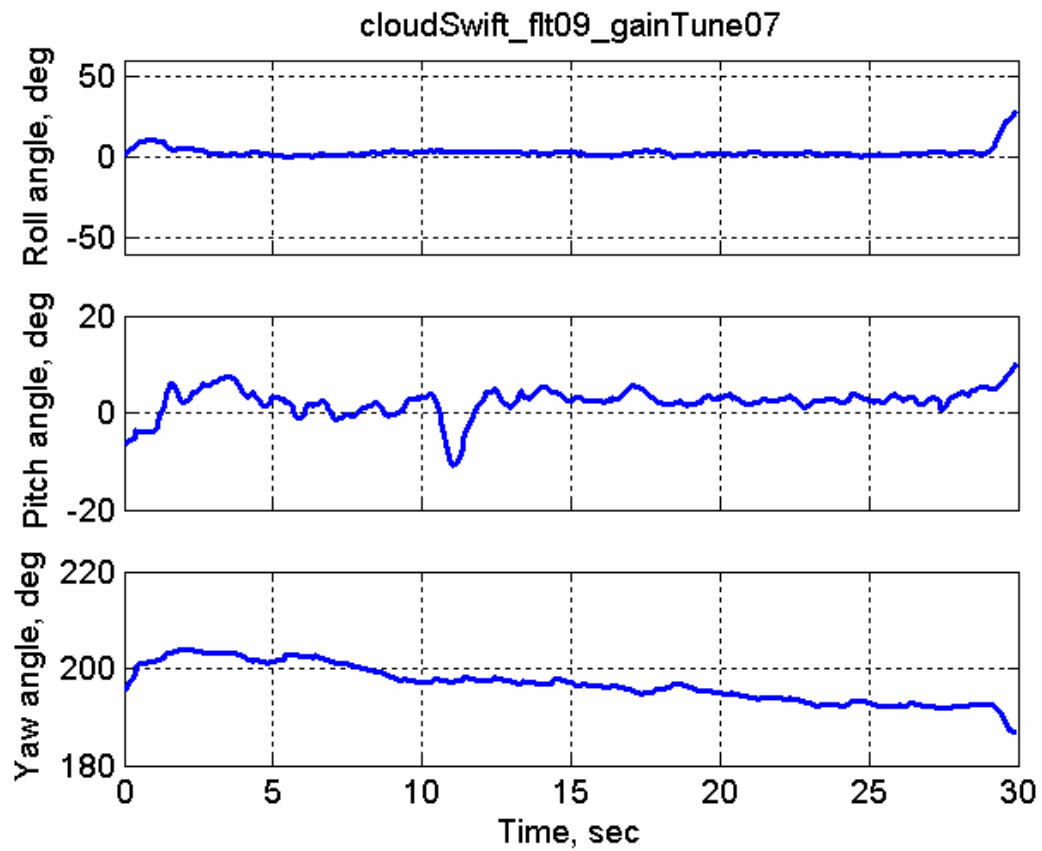




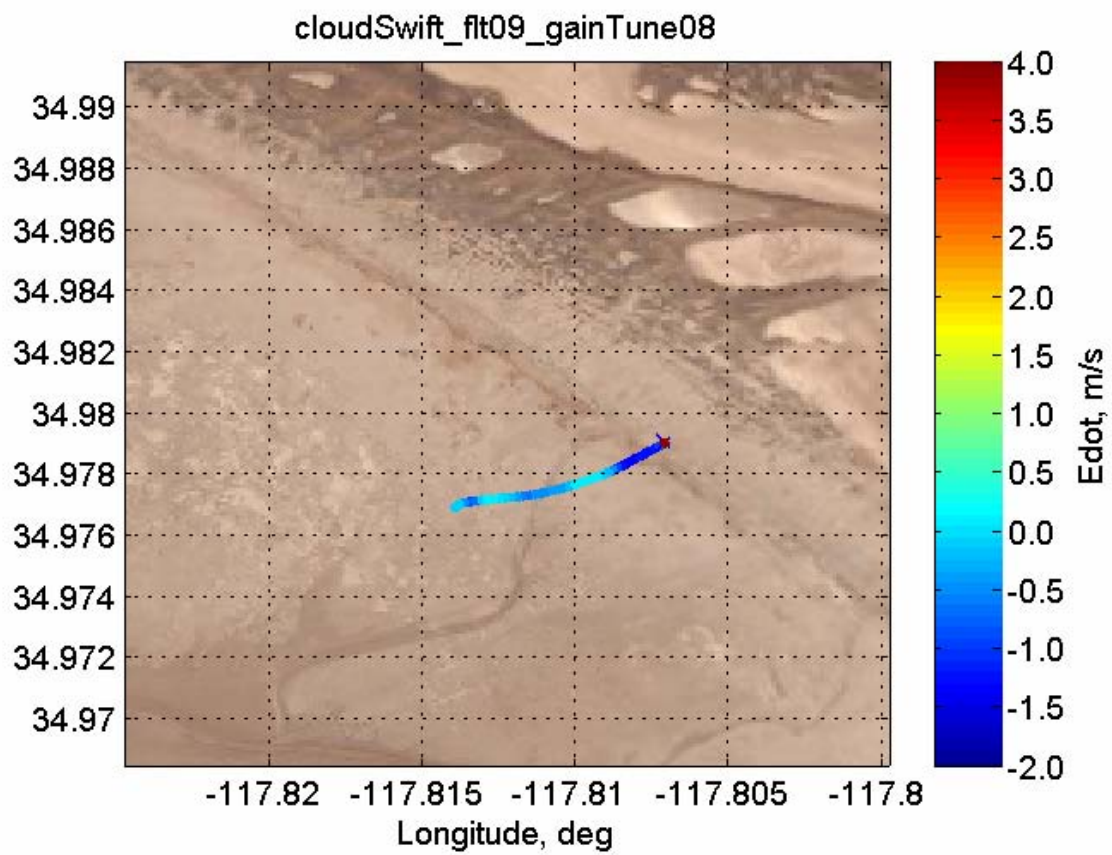
Flight 9, gain tune 7

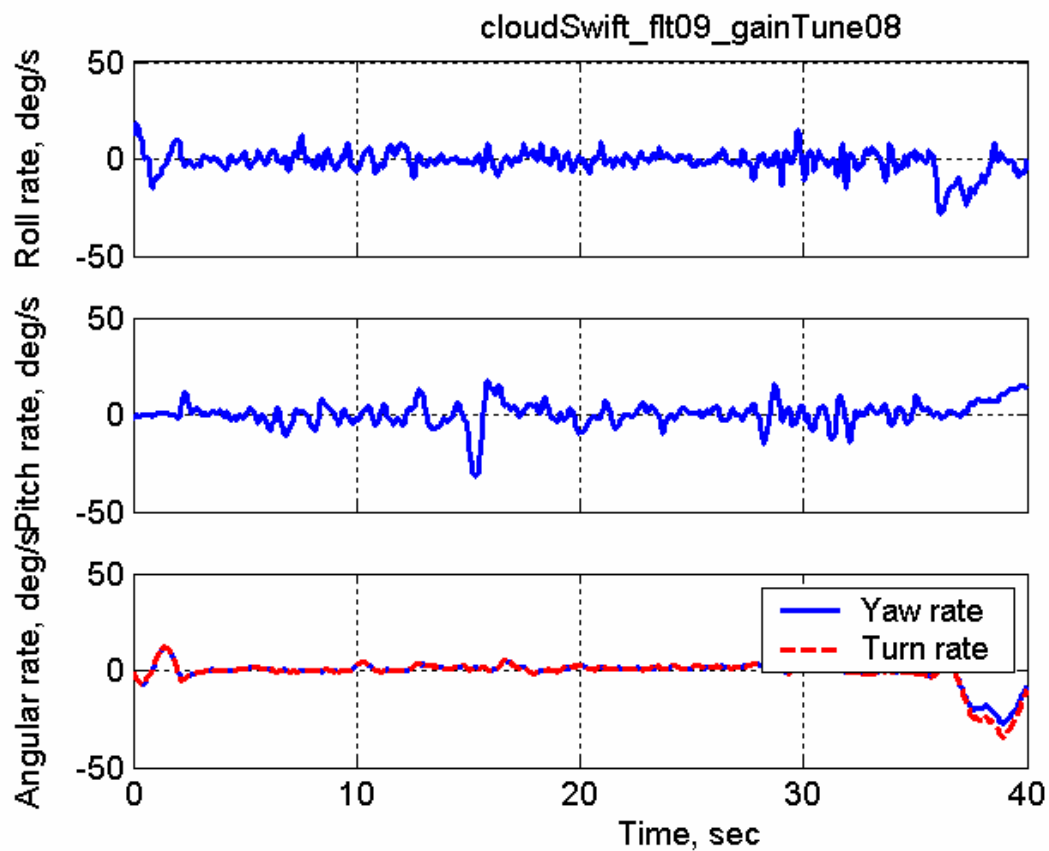
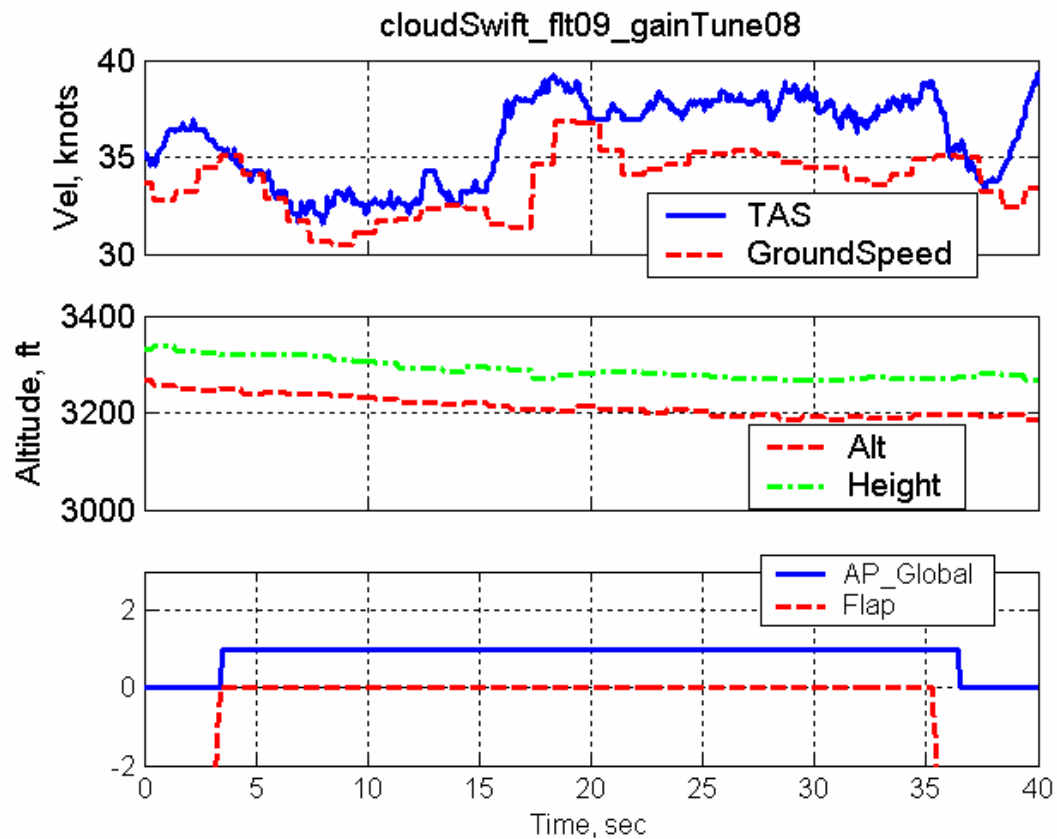


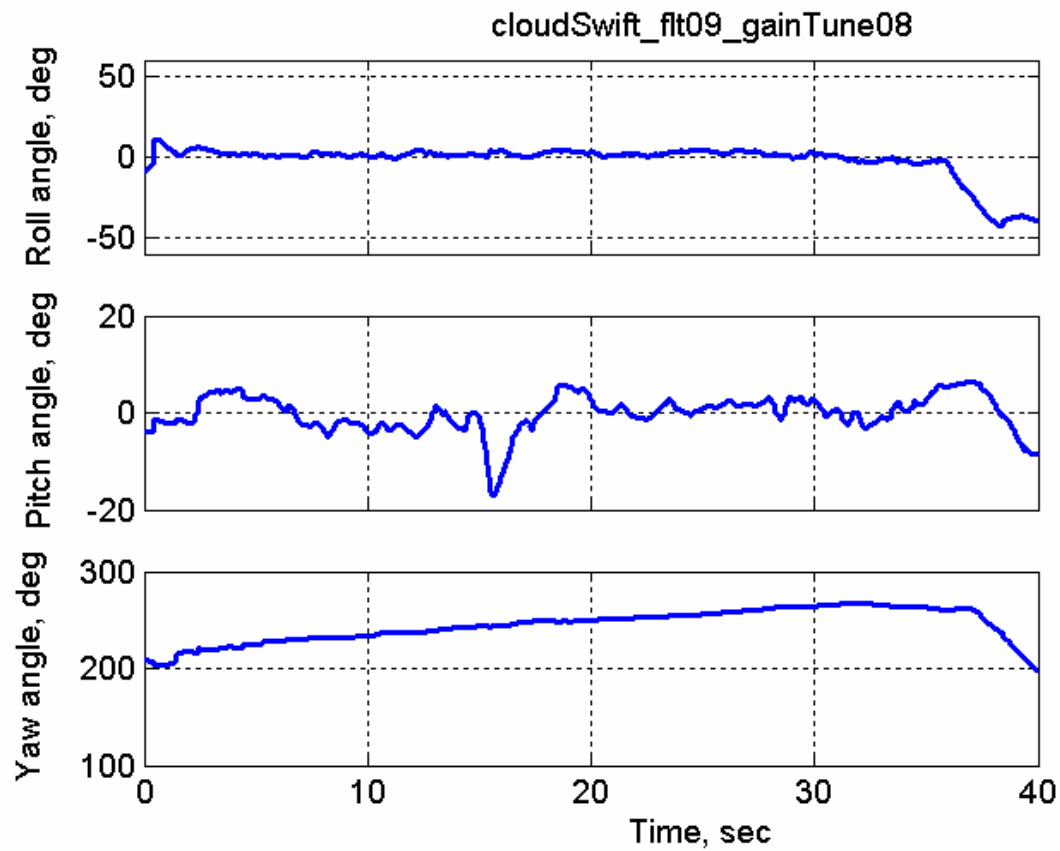




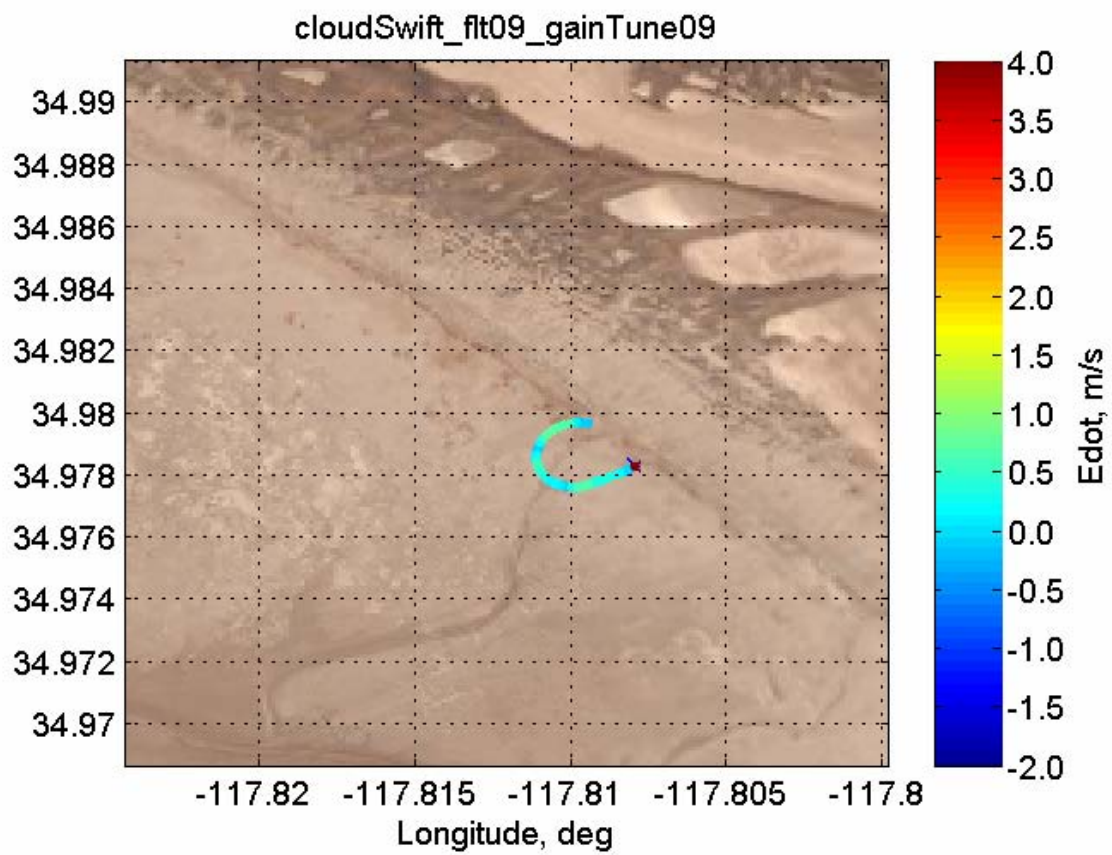
Flight 9, gain tune 8

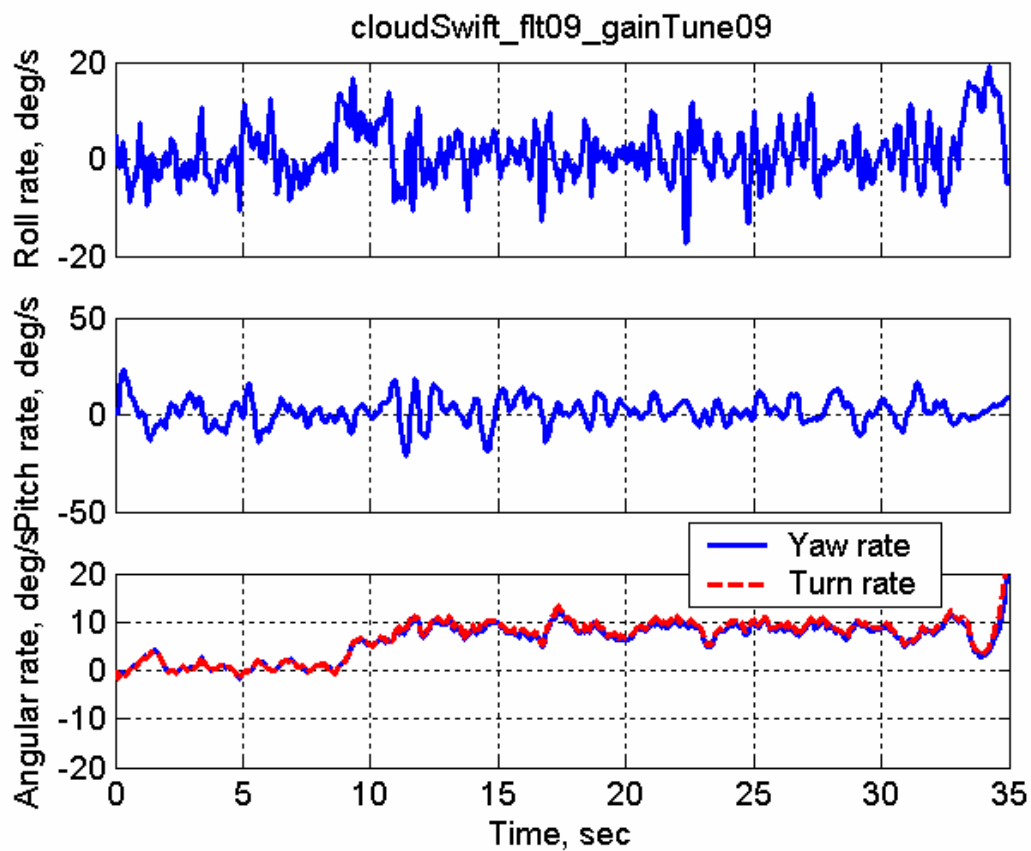
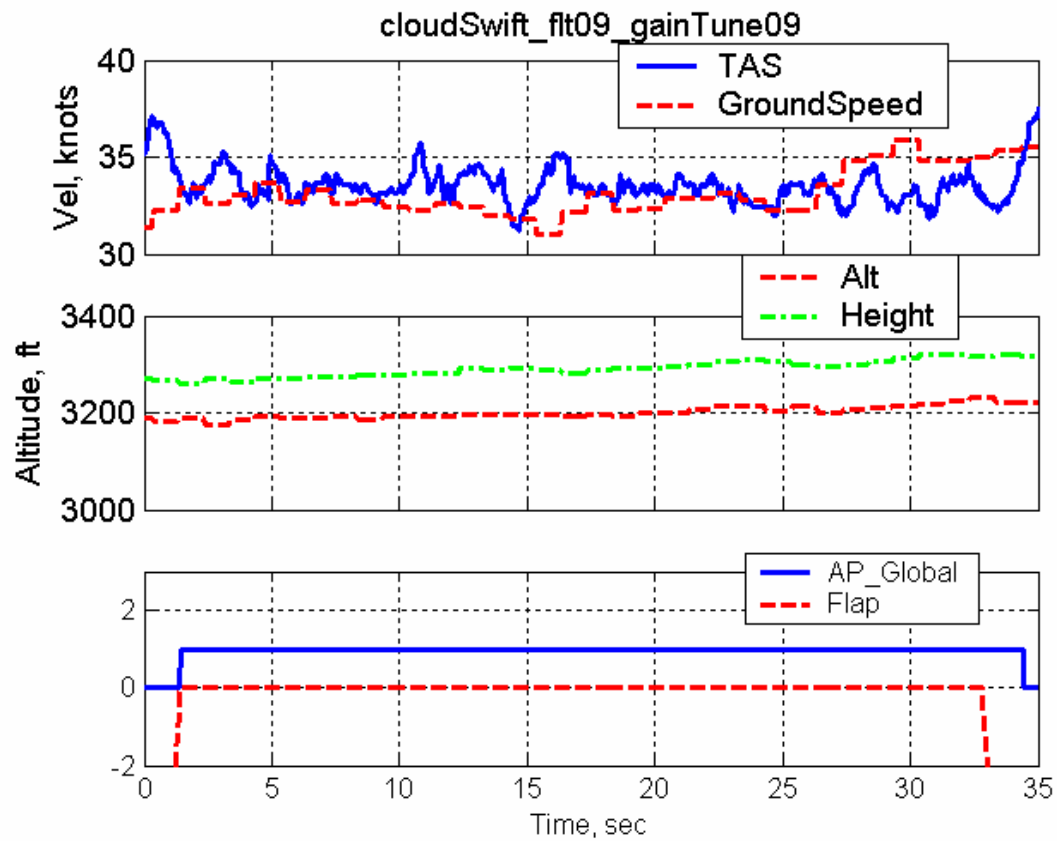


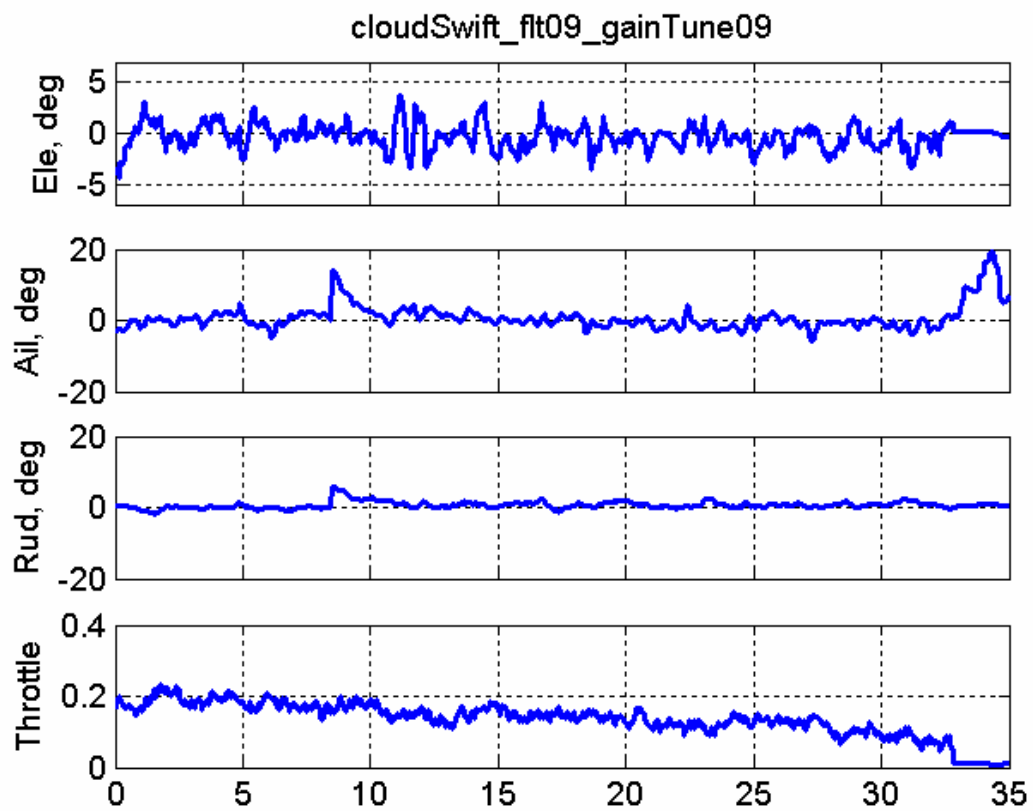
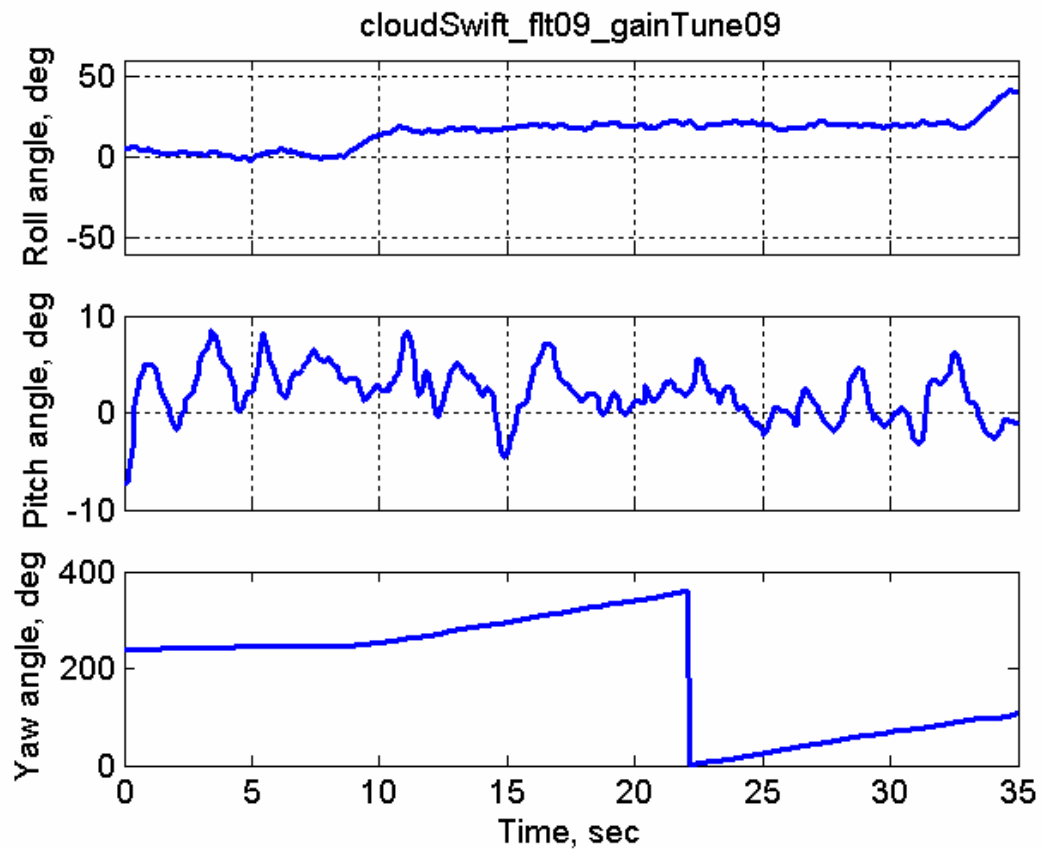




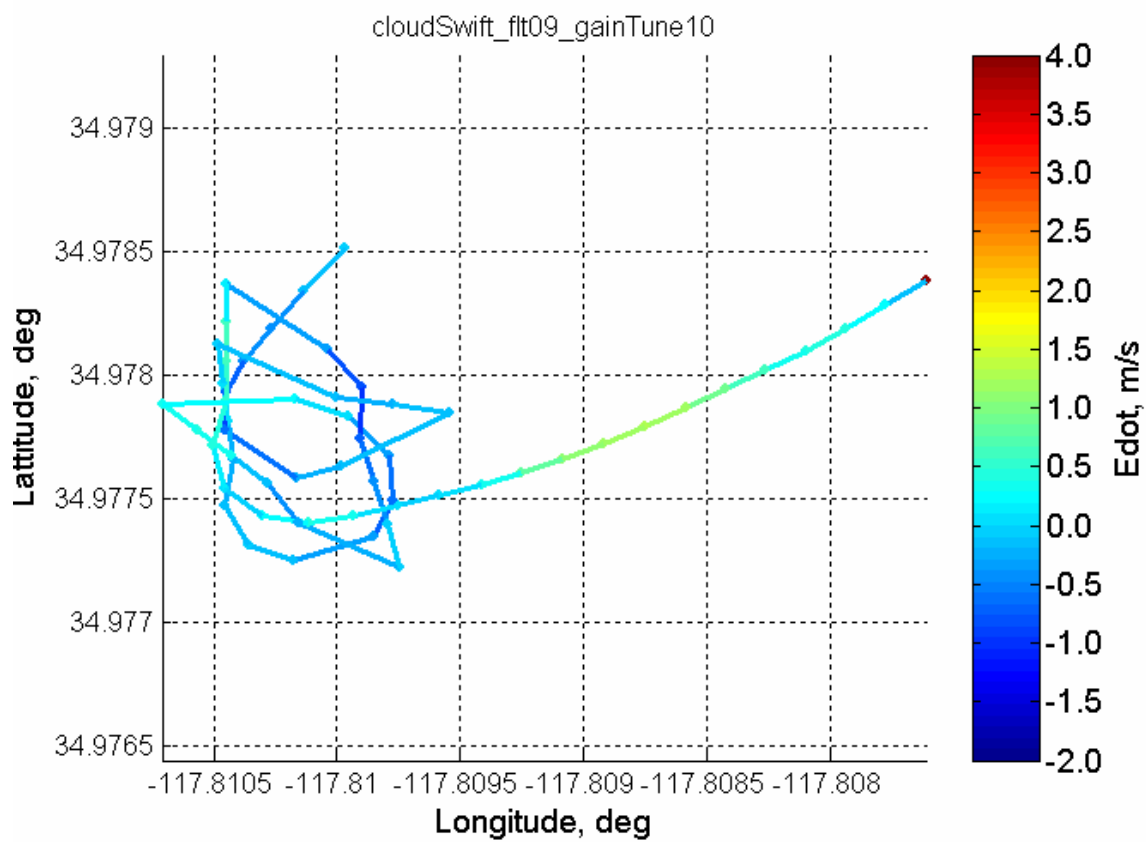
Flight 9, gain tune 9

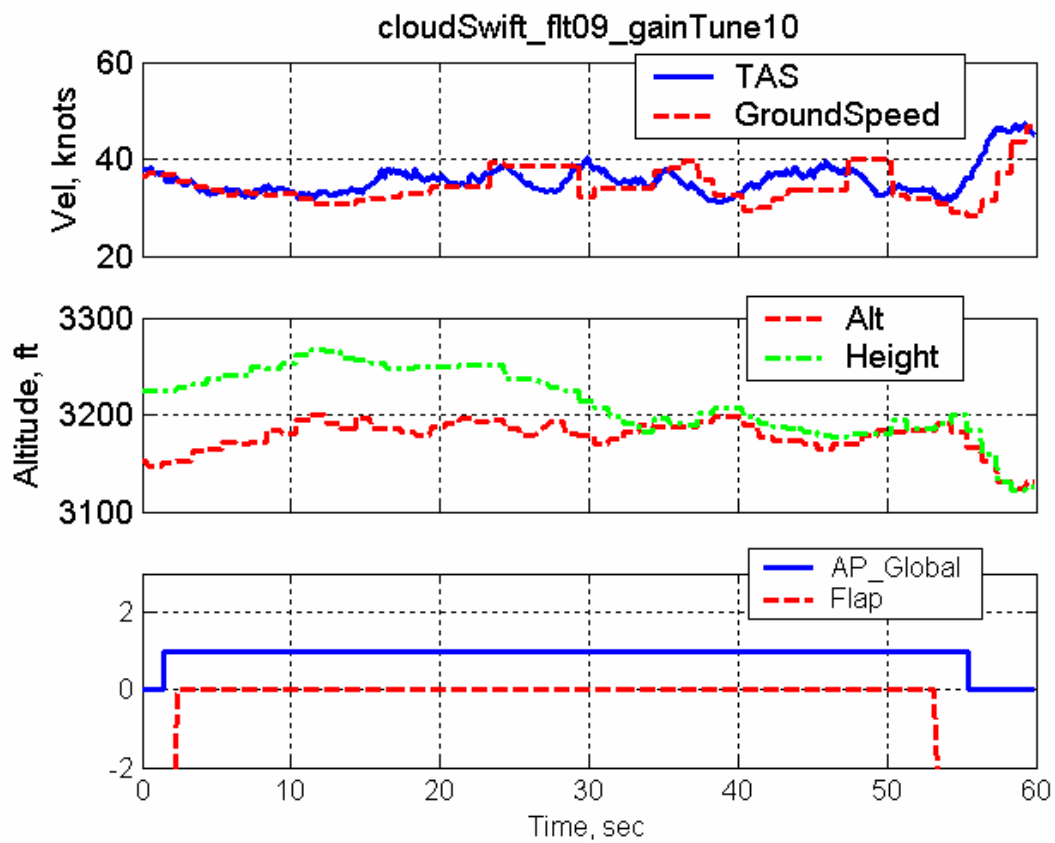
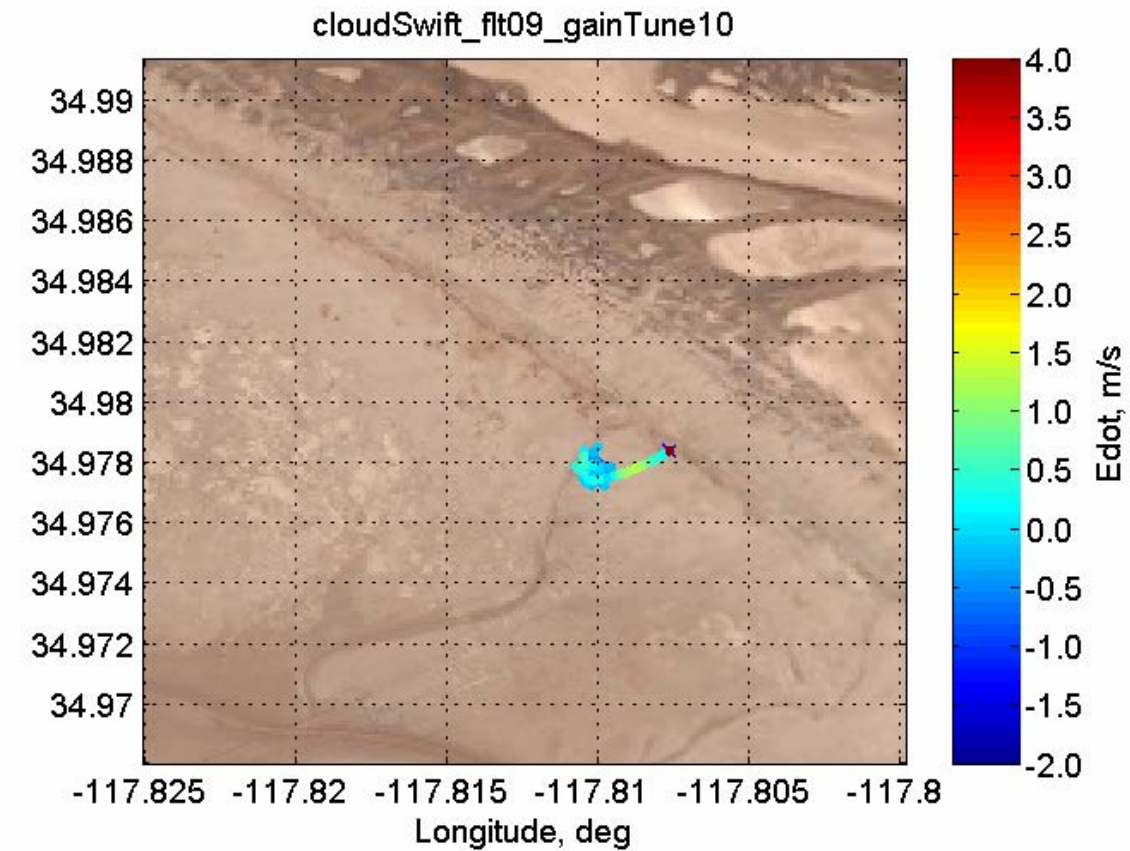


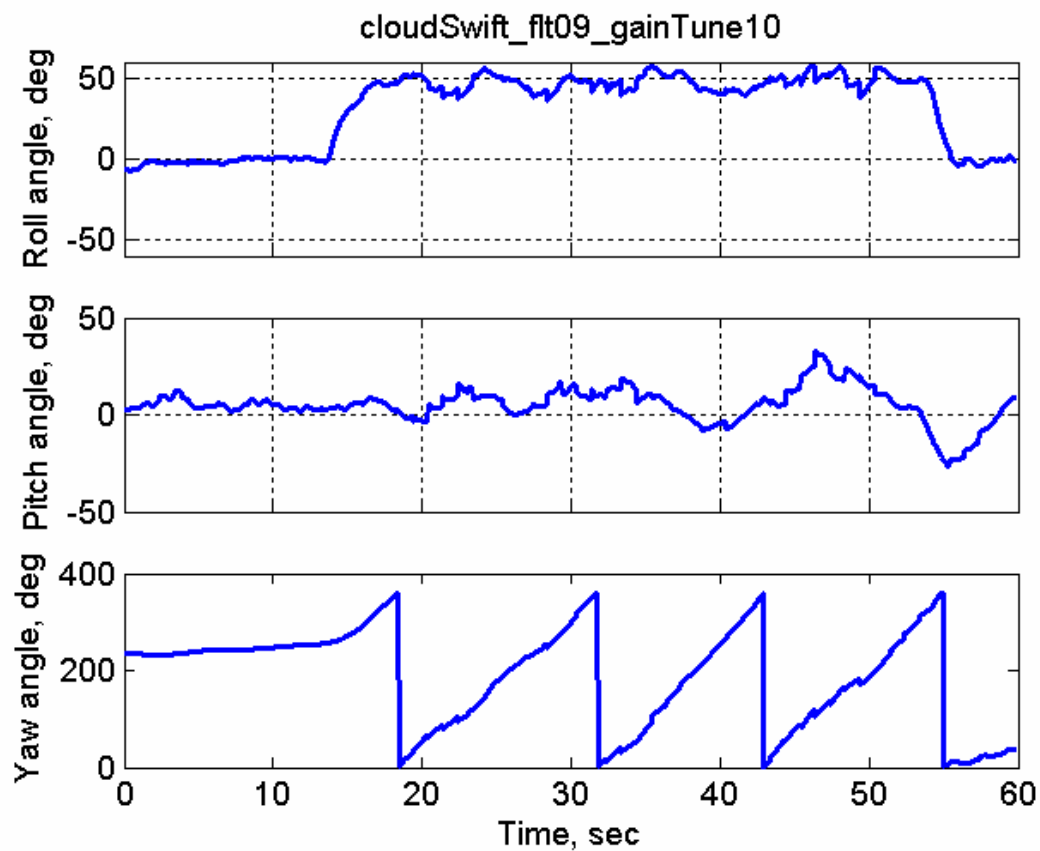
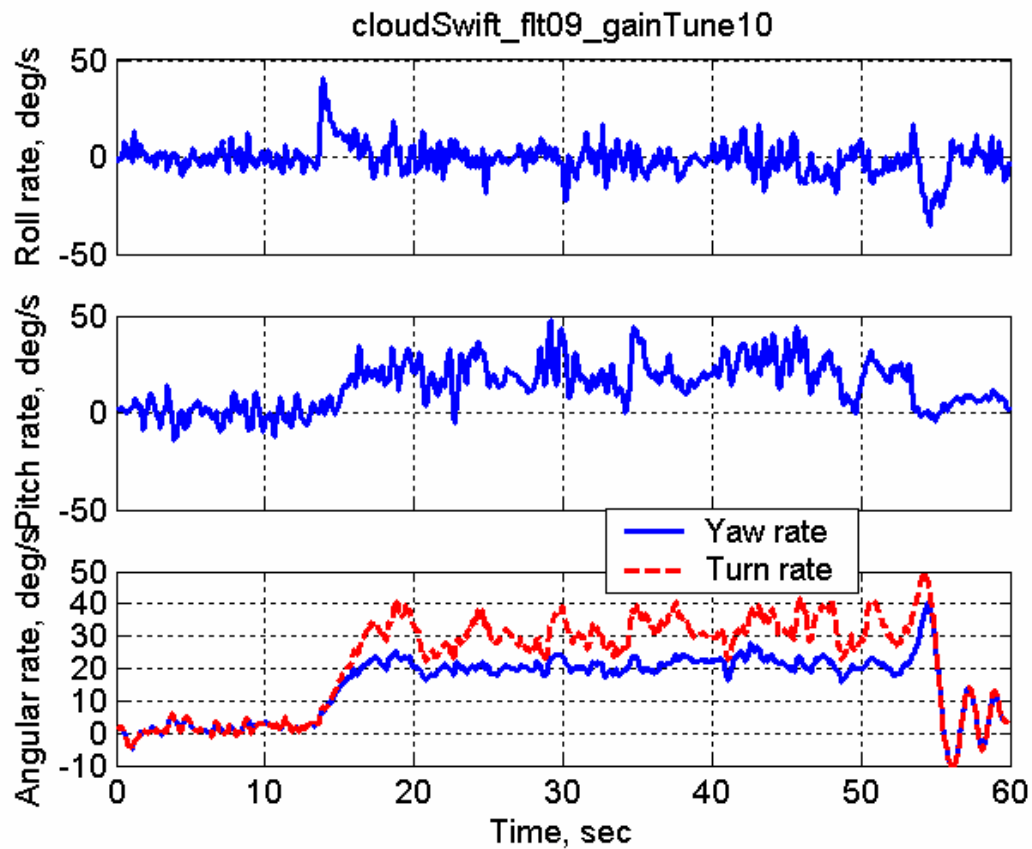




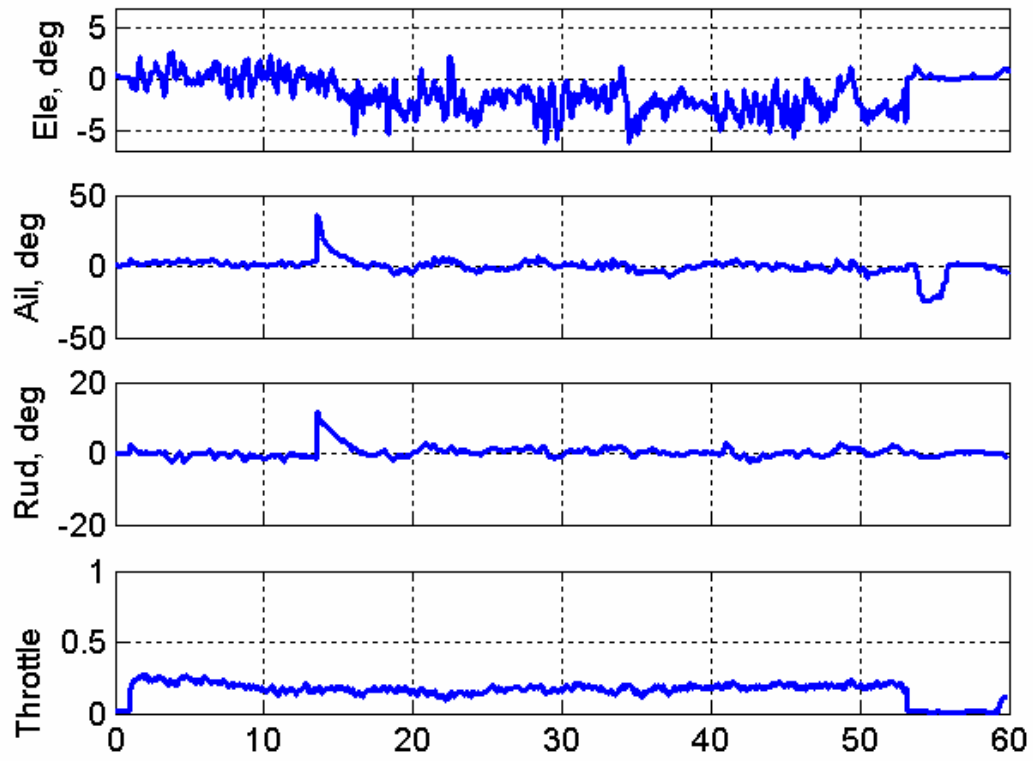
Flight 9, gain tune 10





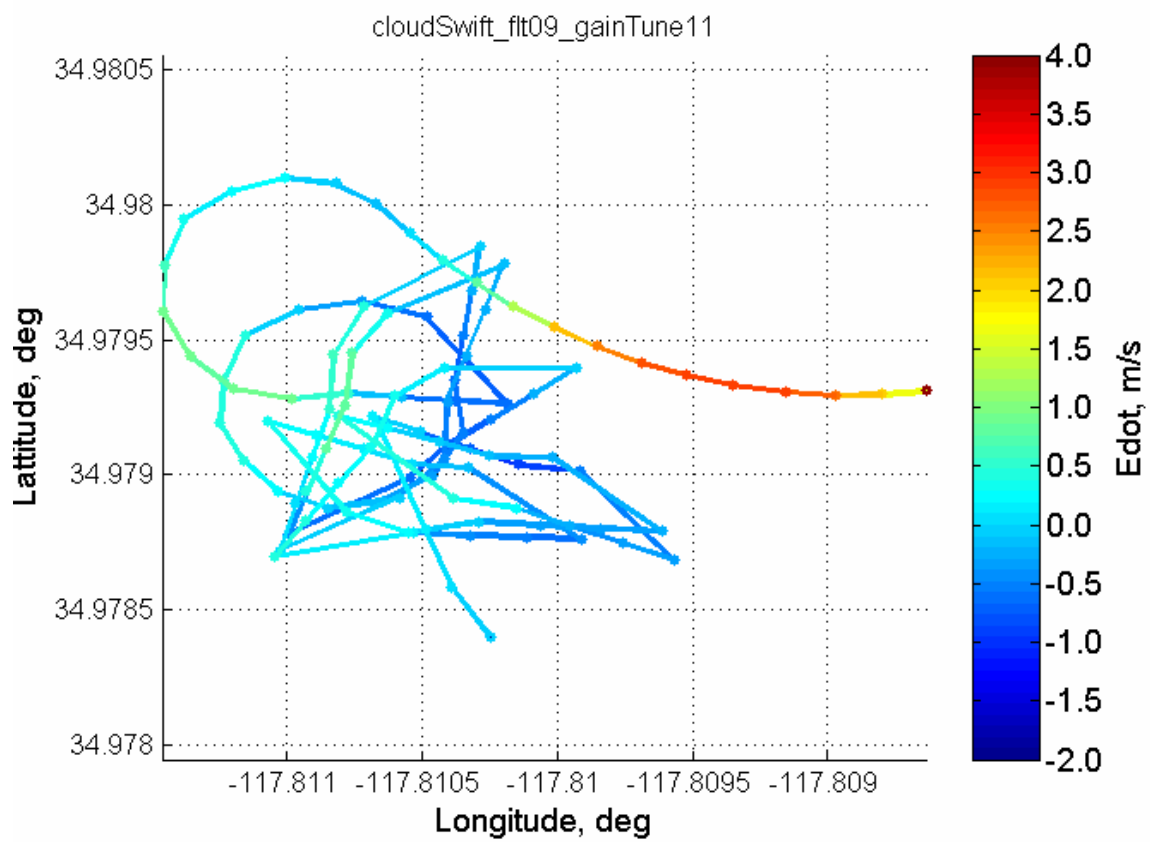


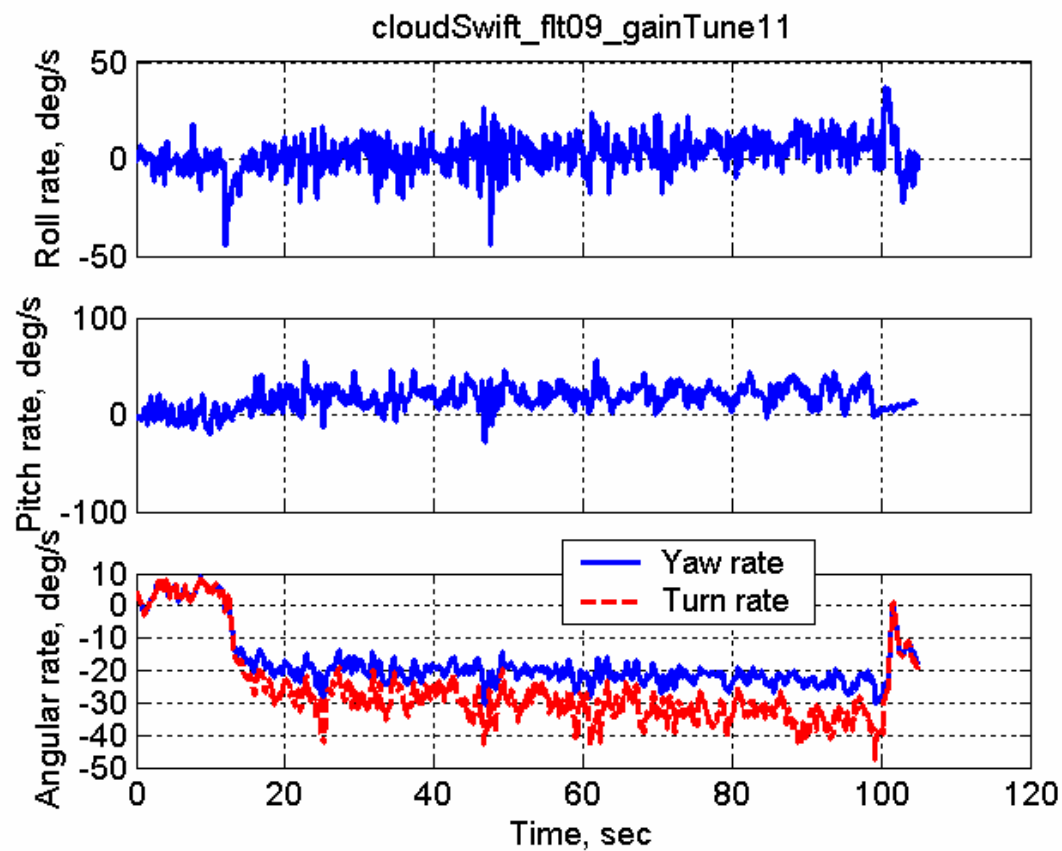
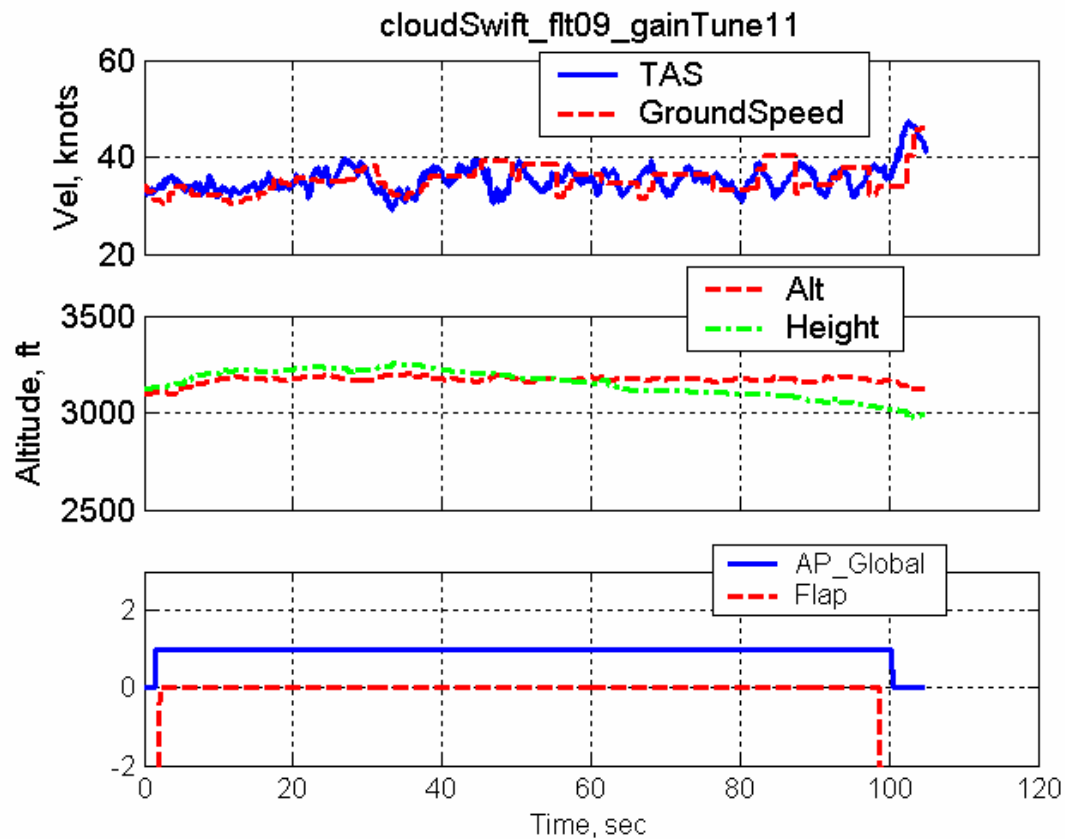
cloudSwift_ft09_gainTune10

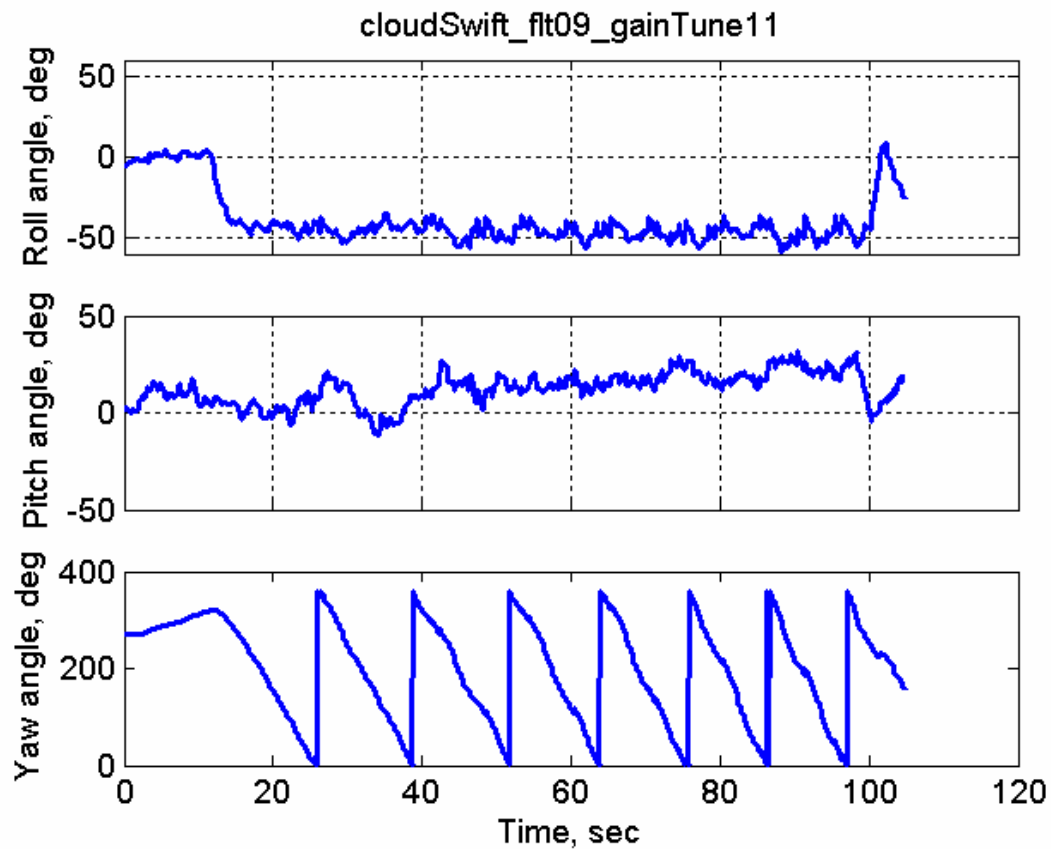


Flight 9, gain tune 11

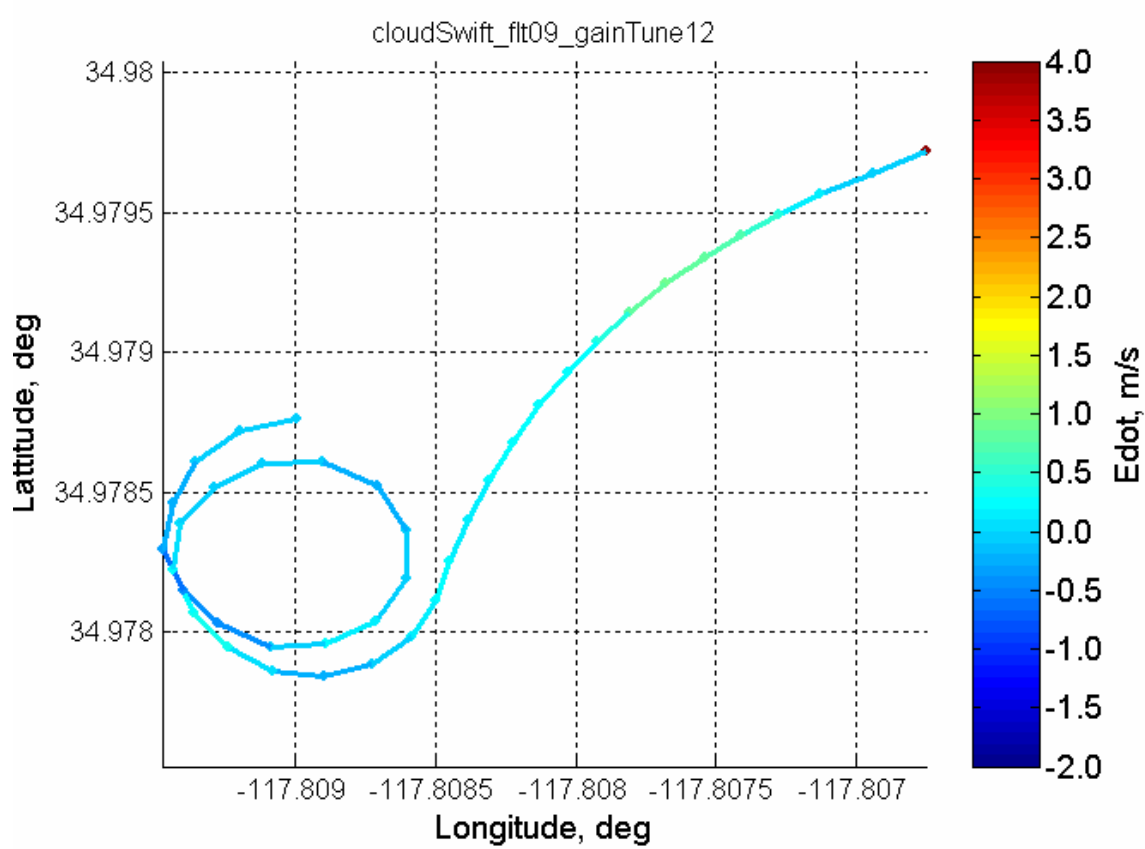
This file shows GPS problems well.

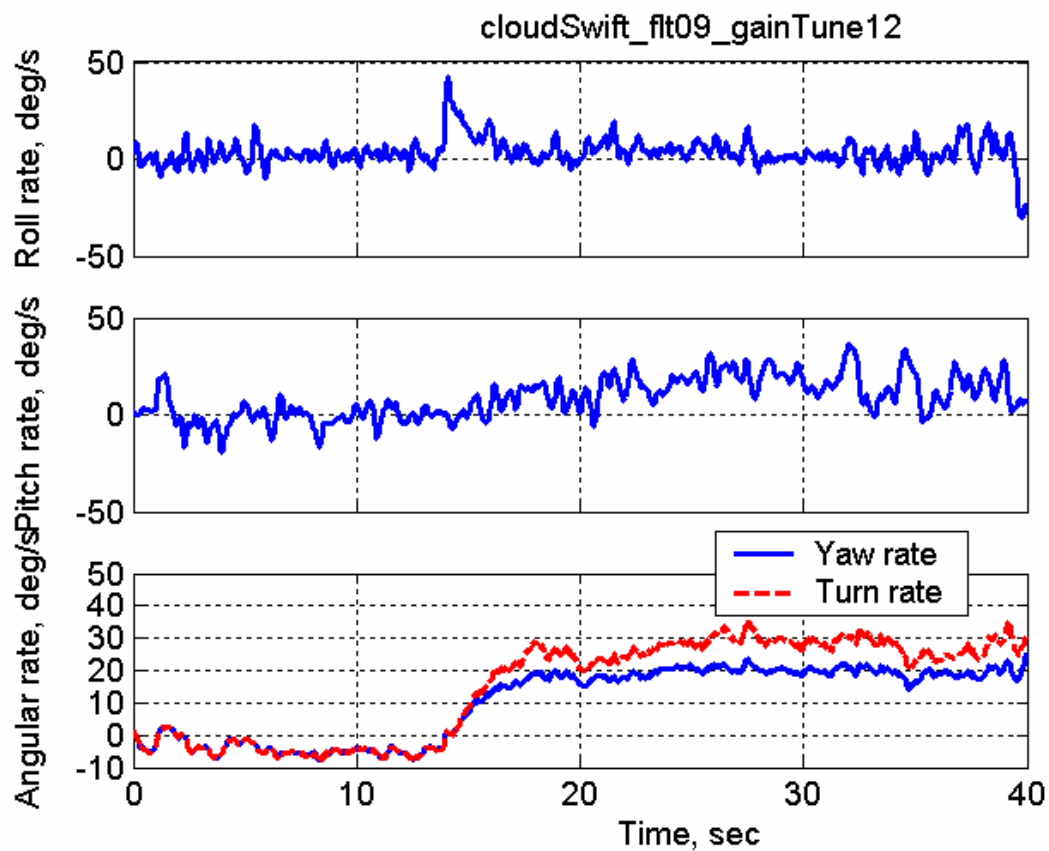
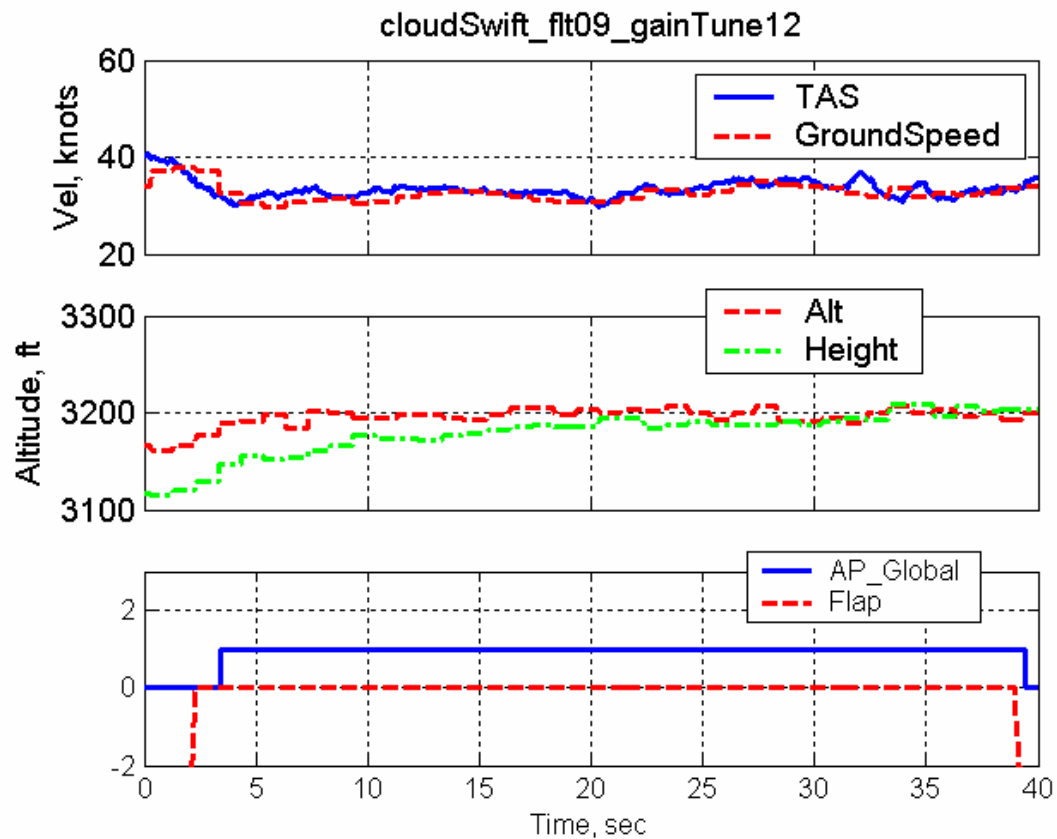


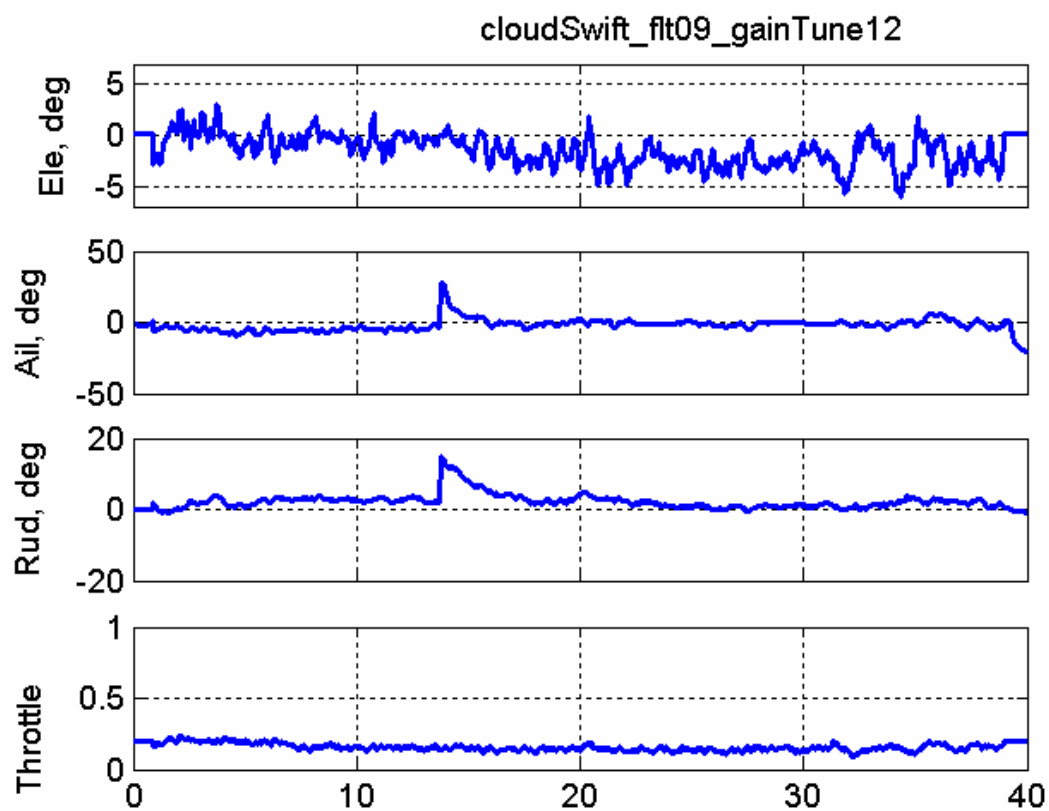
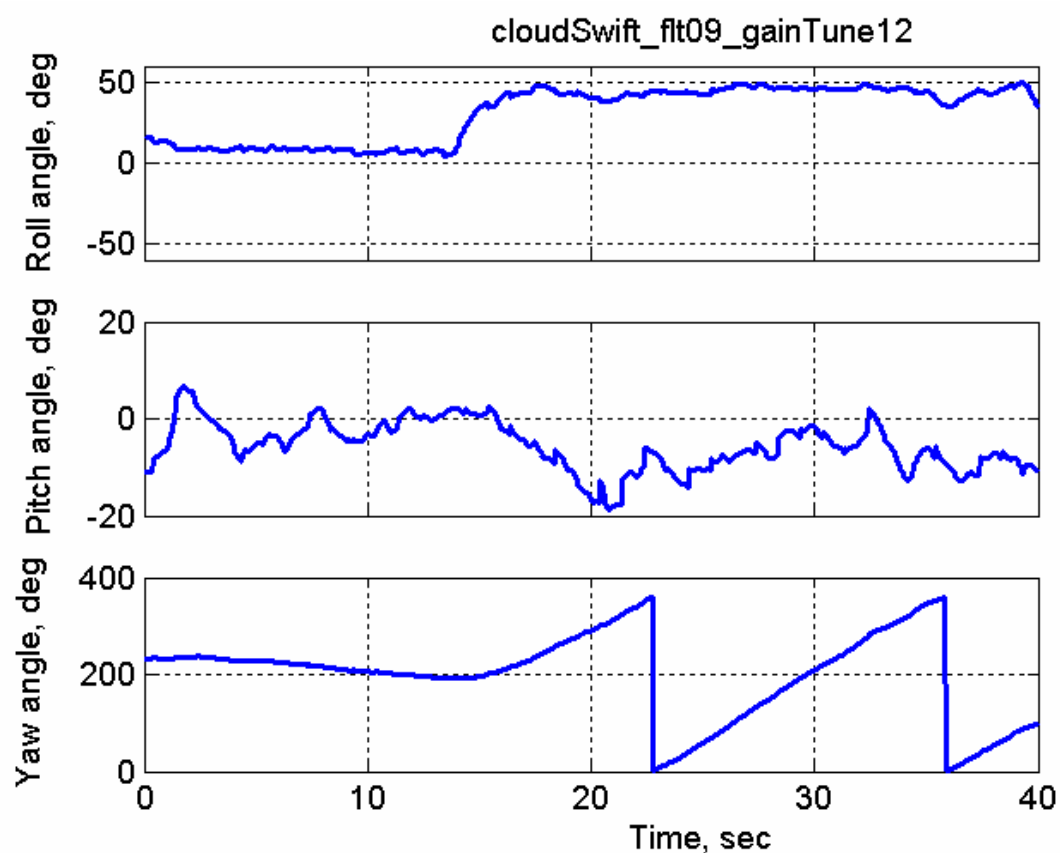




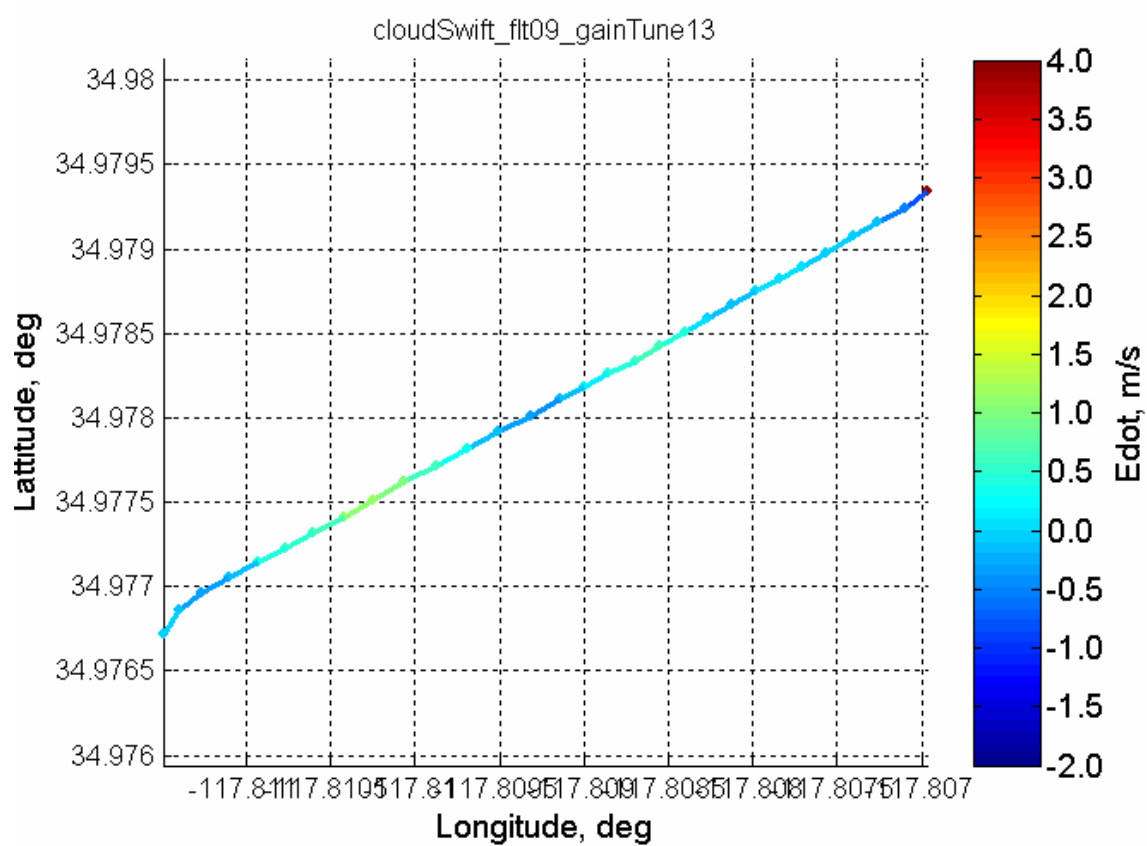
Flight 9, gain tune 12

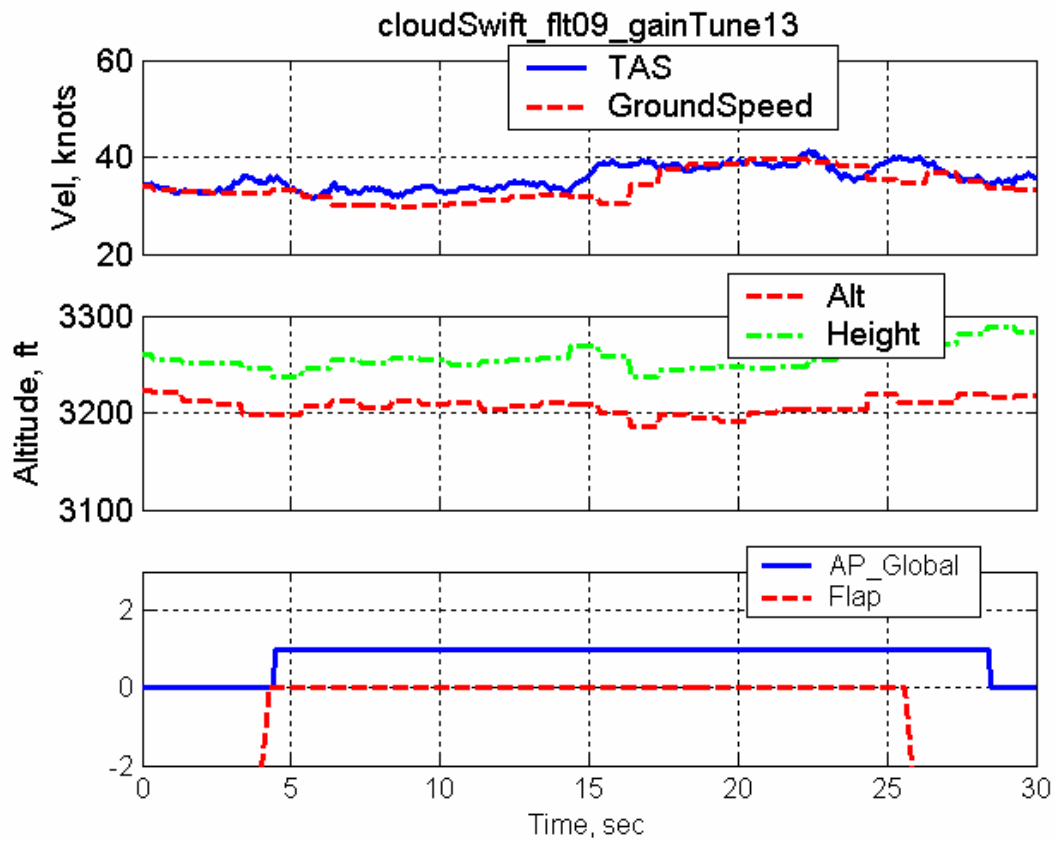
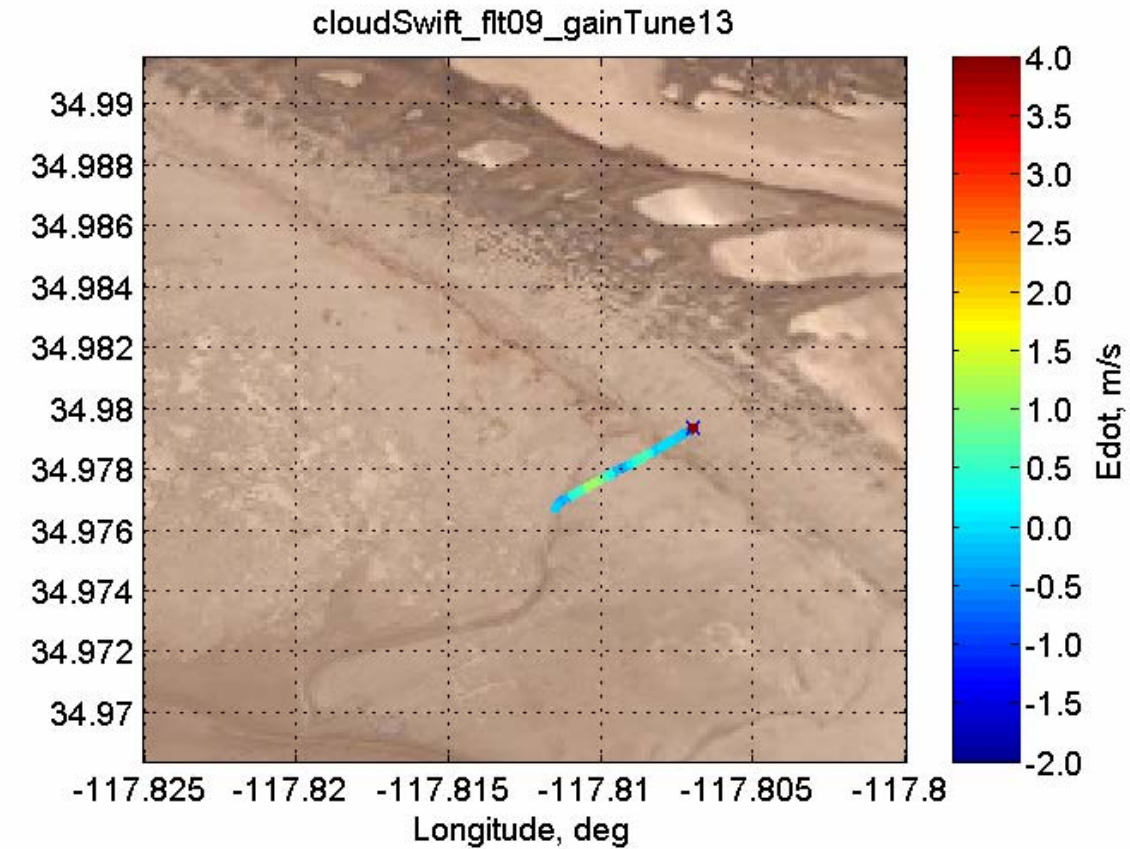


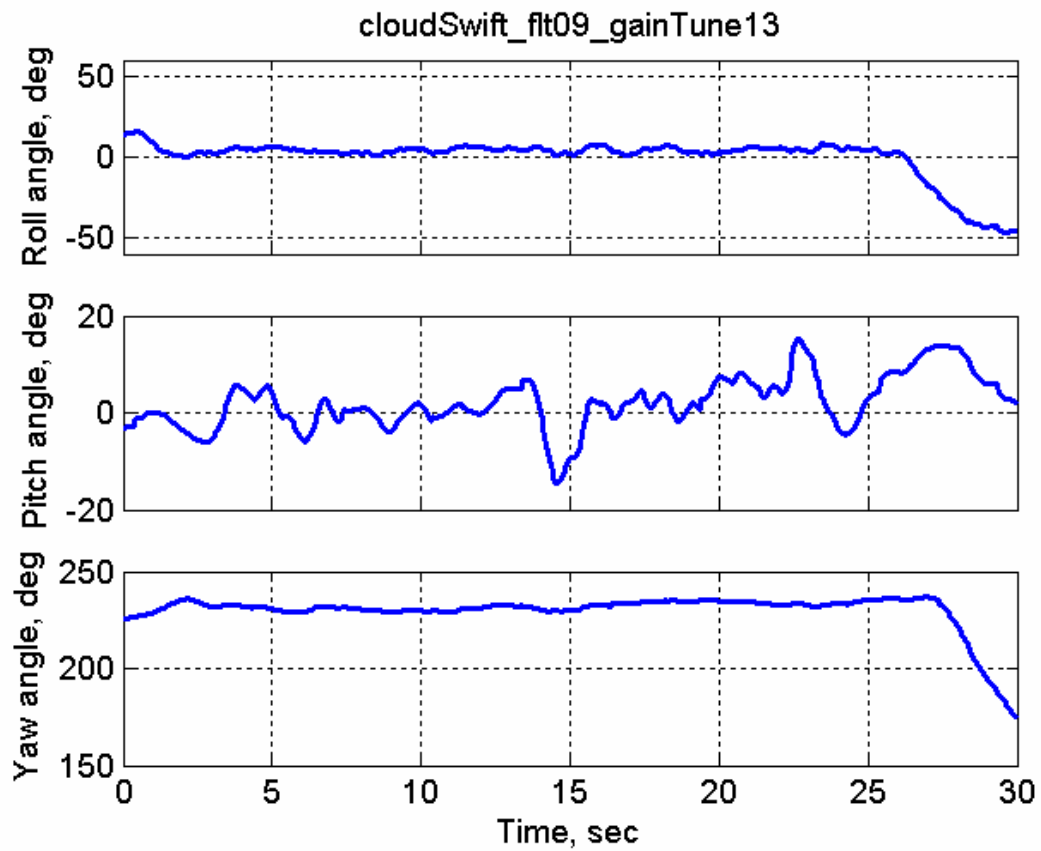
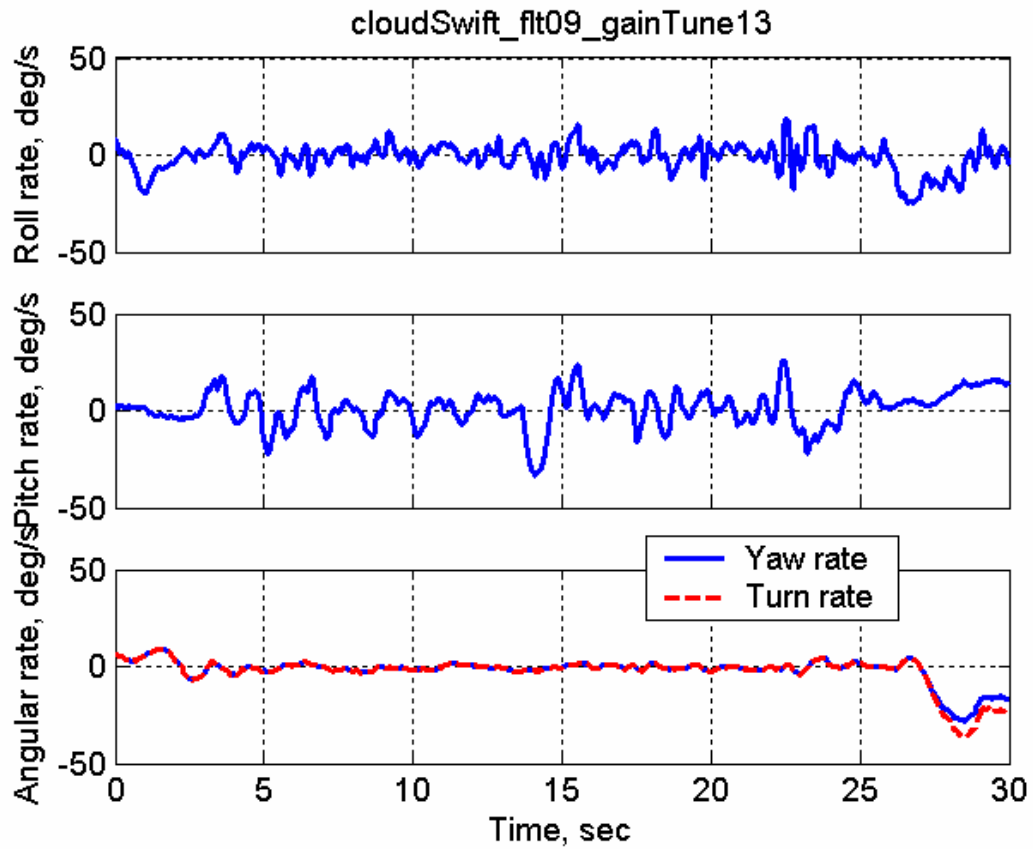


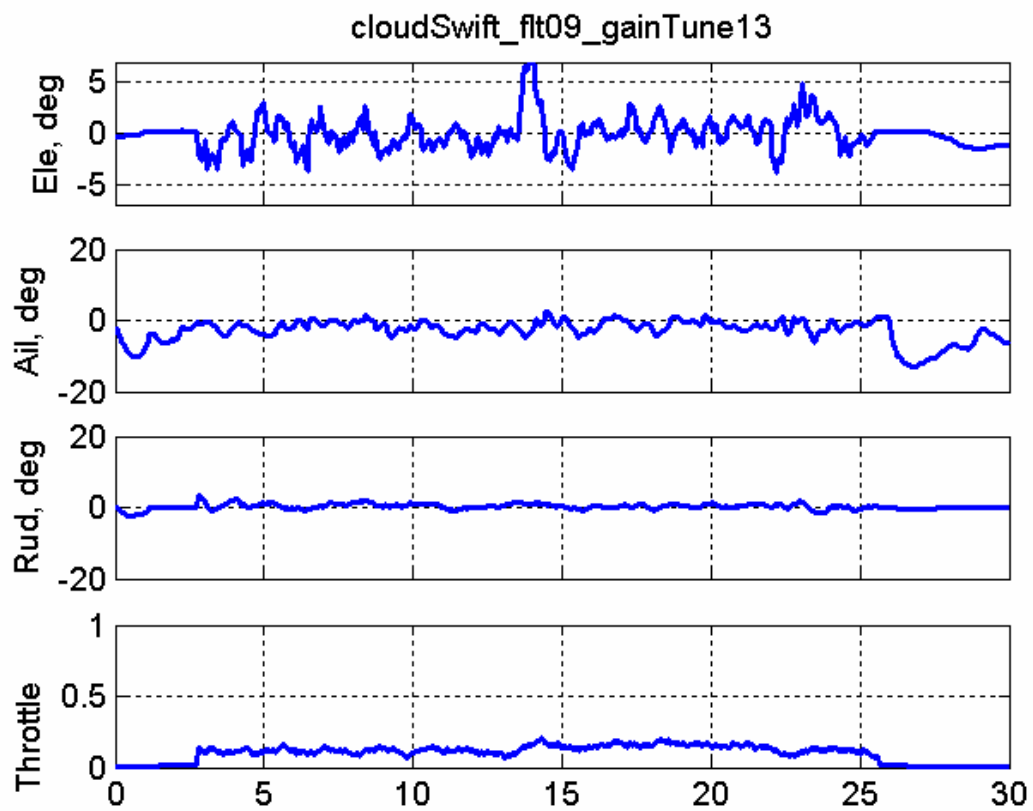


Flight 9, gain tune 13

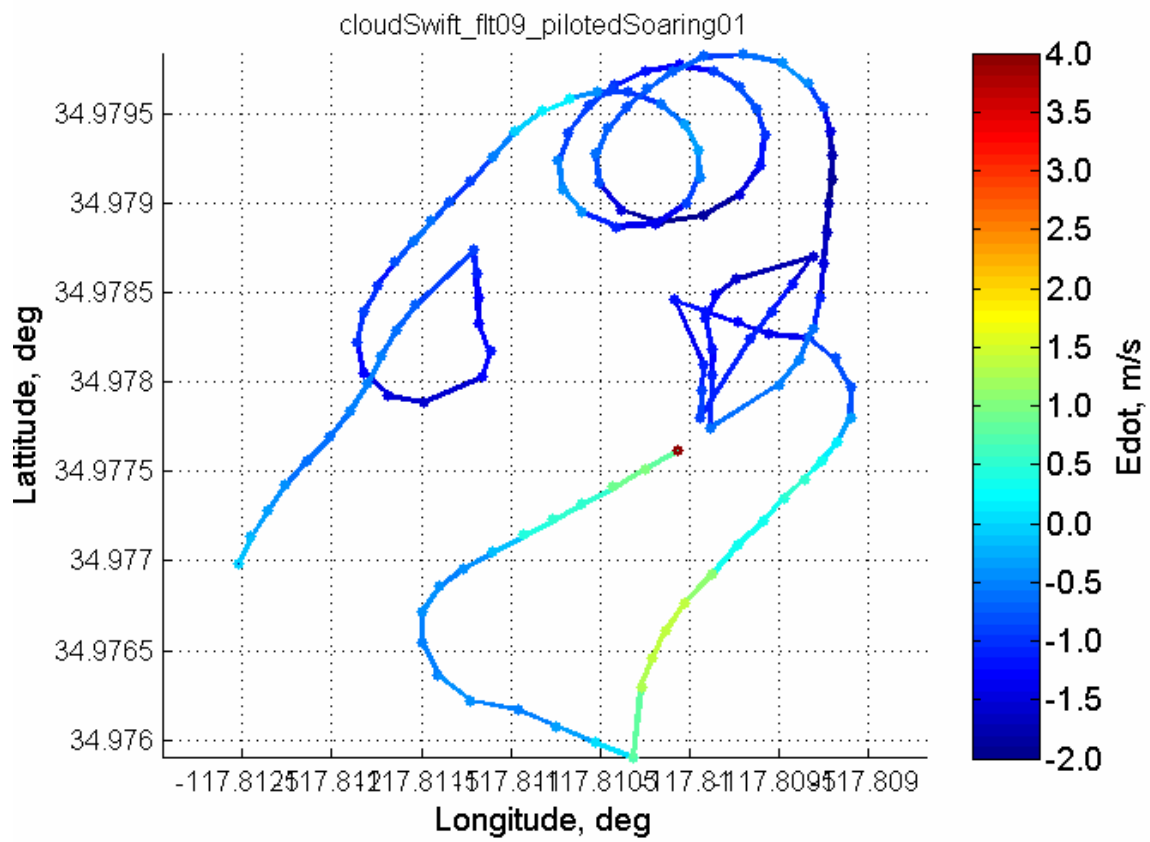


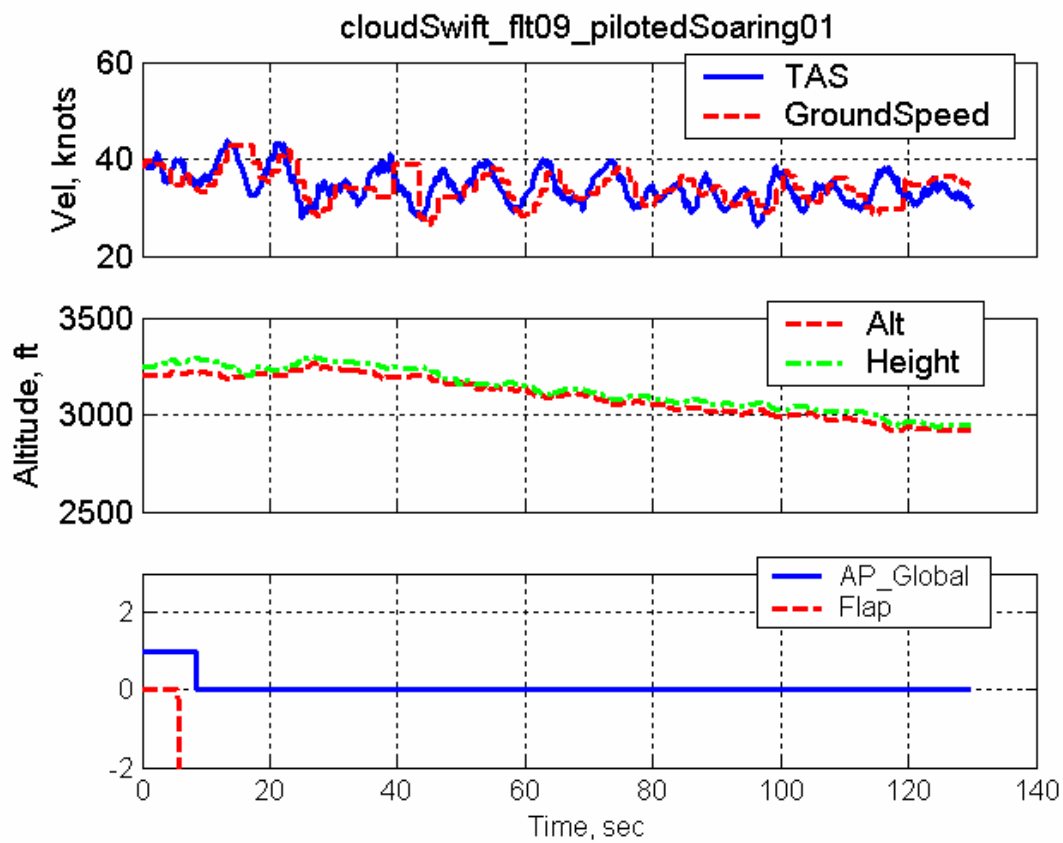
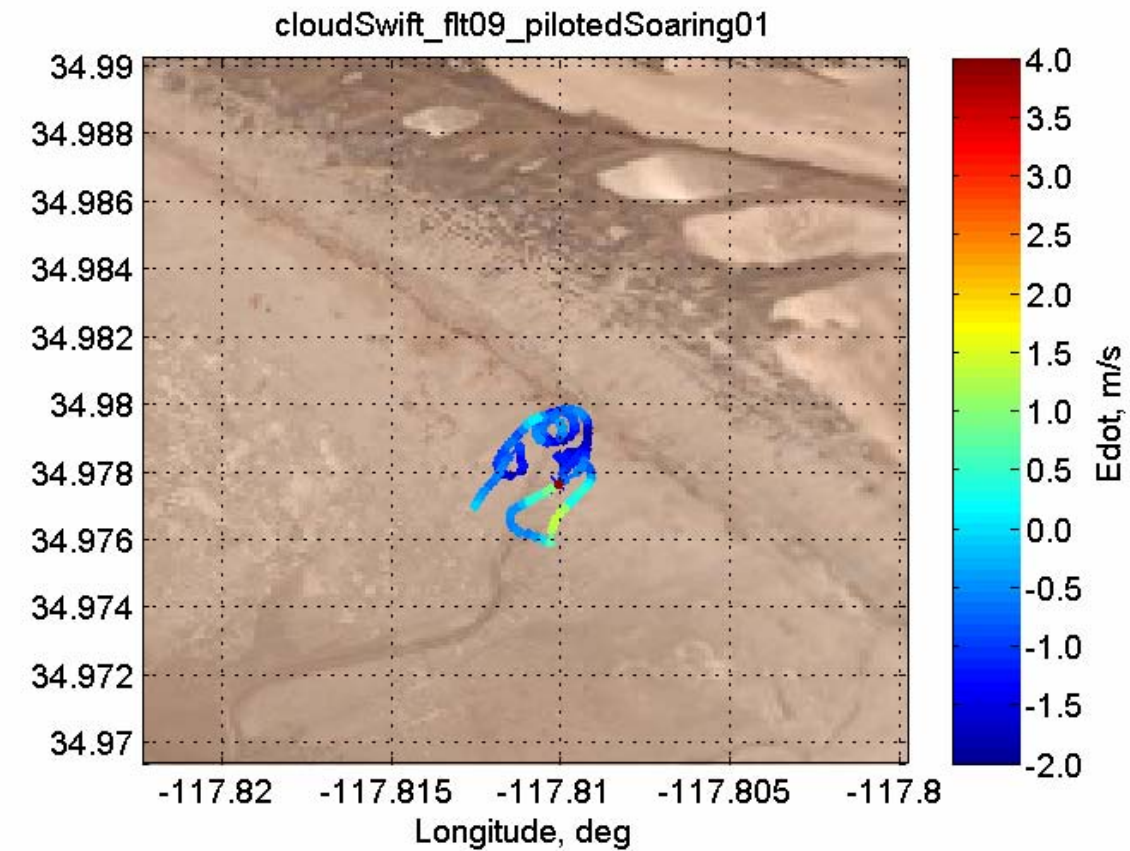


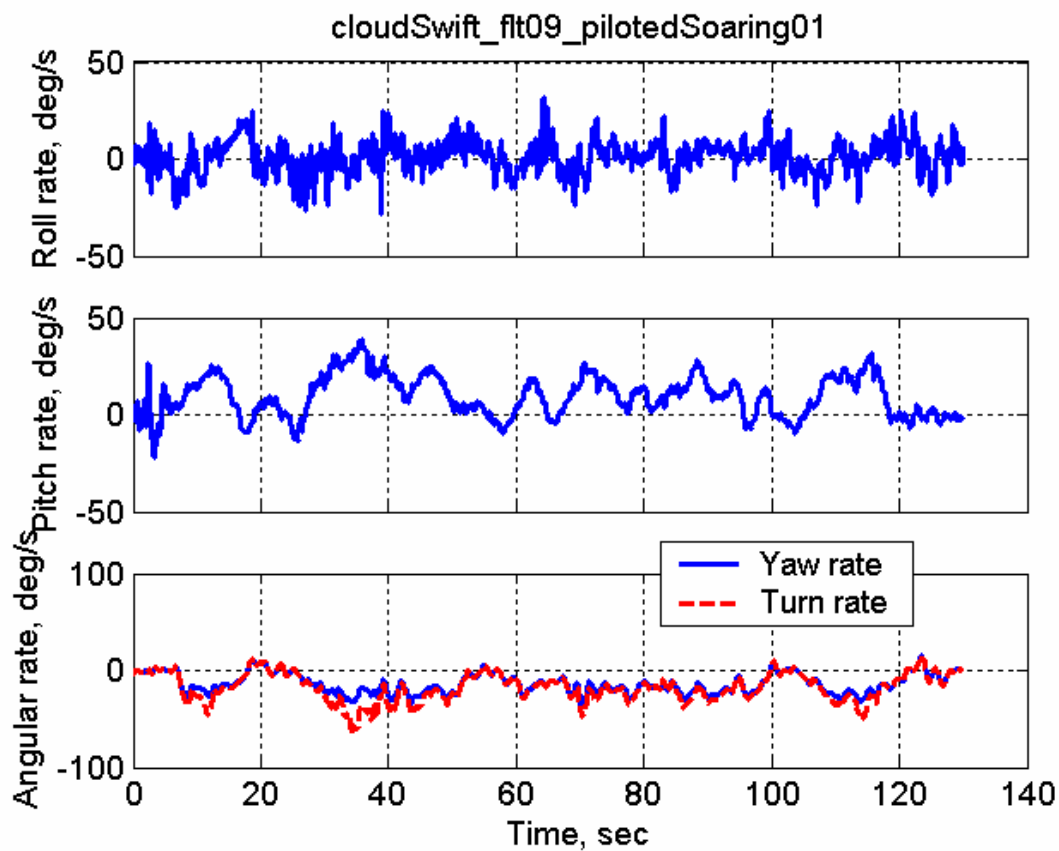
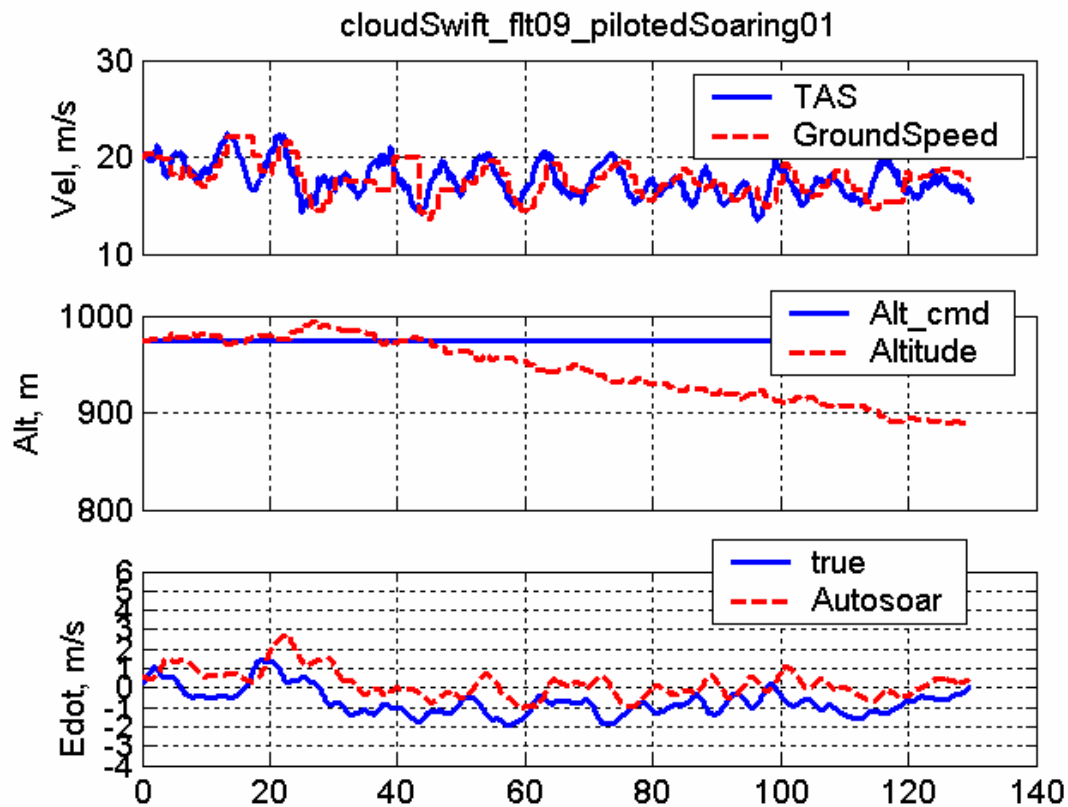


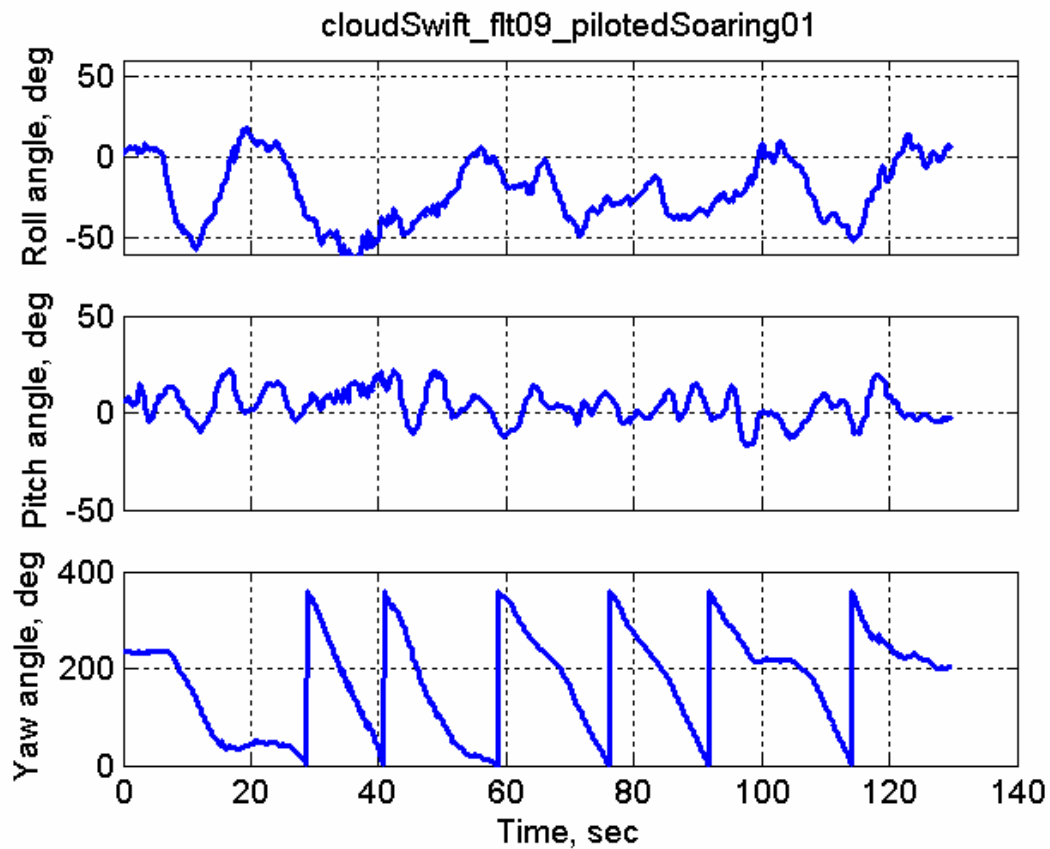


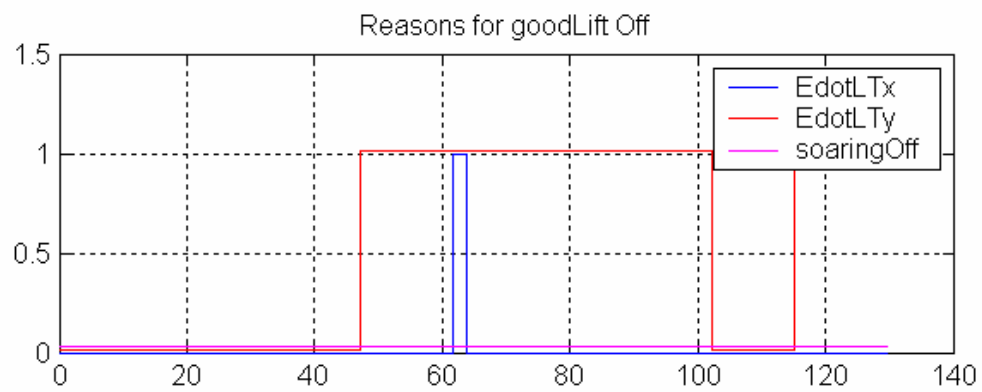
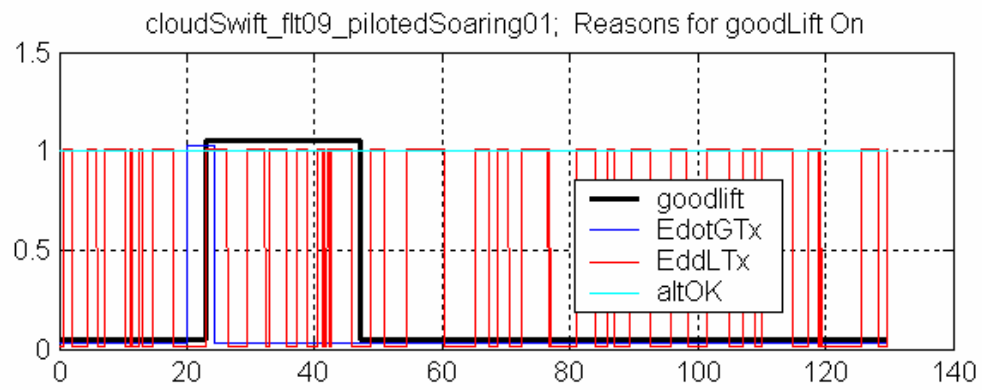
Flight 9, piloted soaring 1



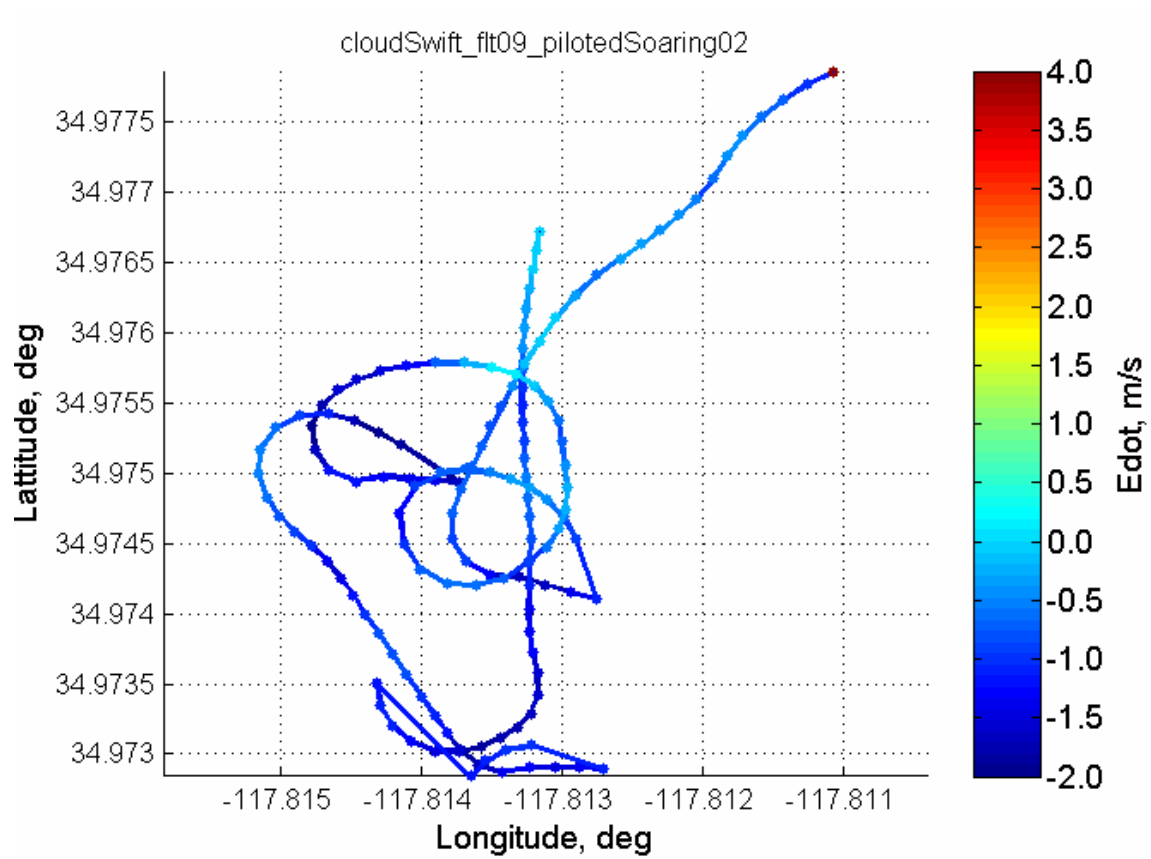


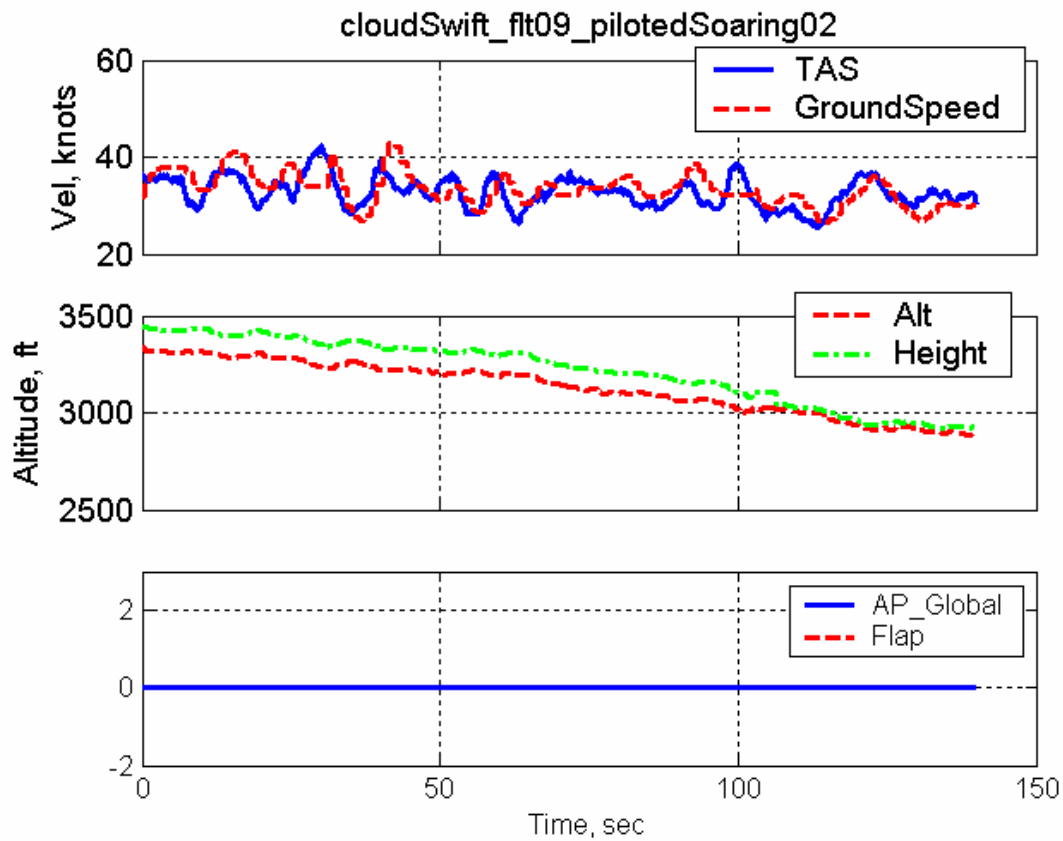
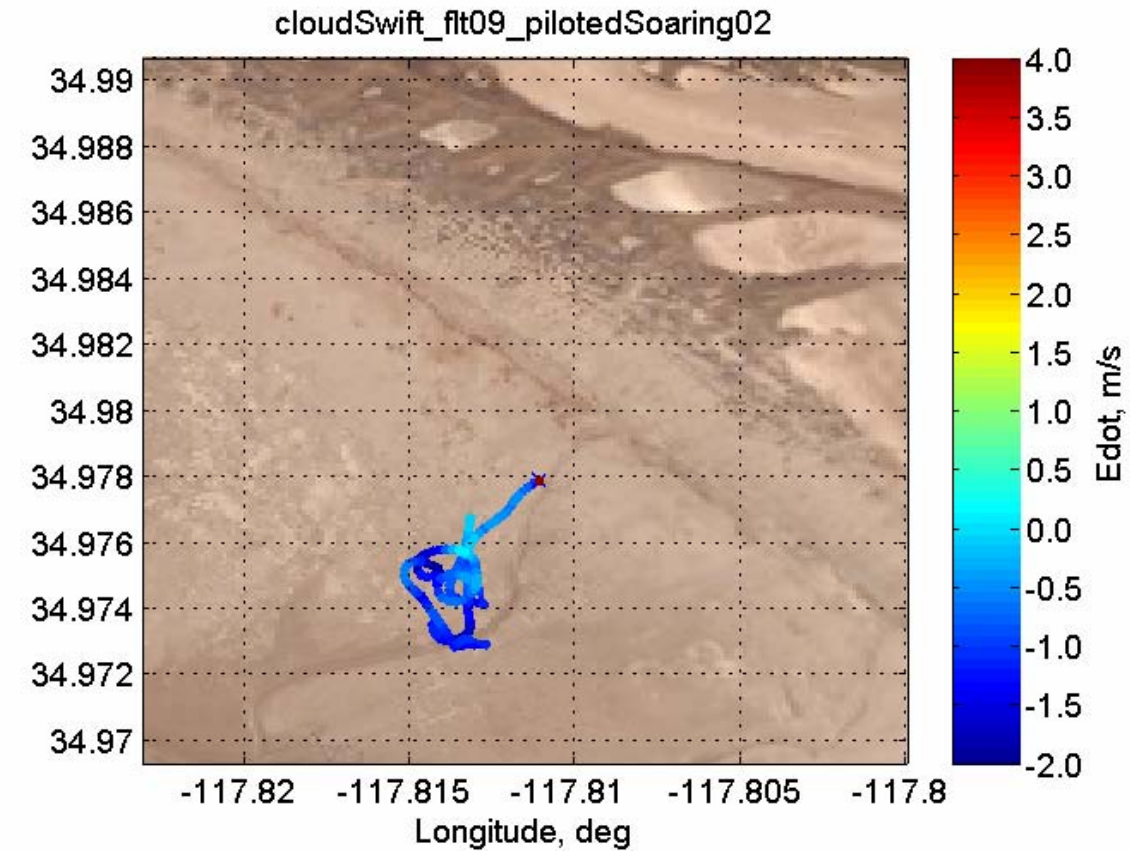


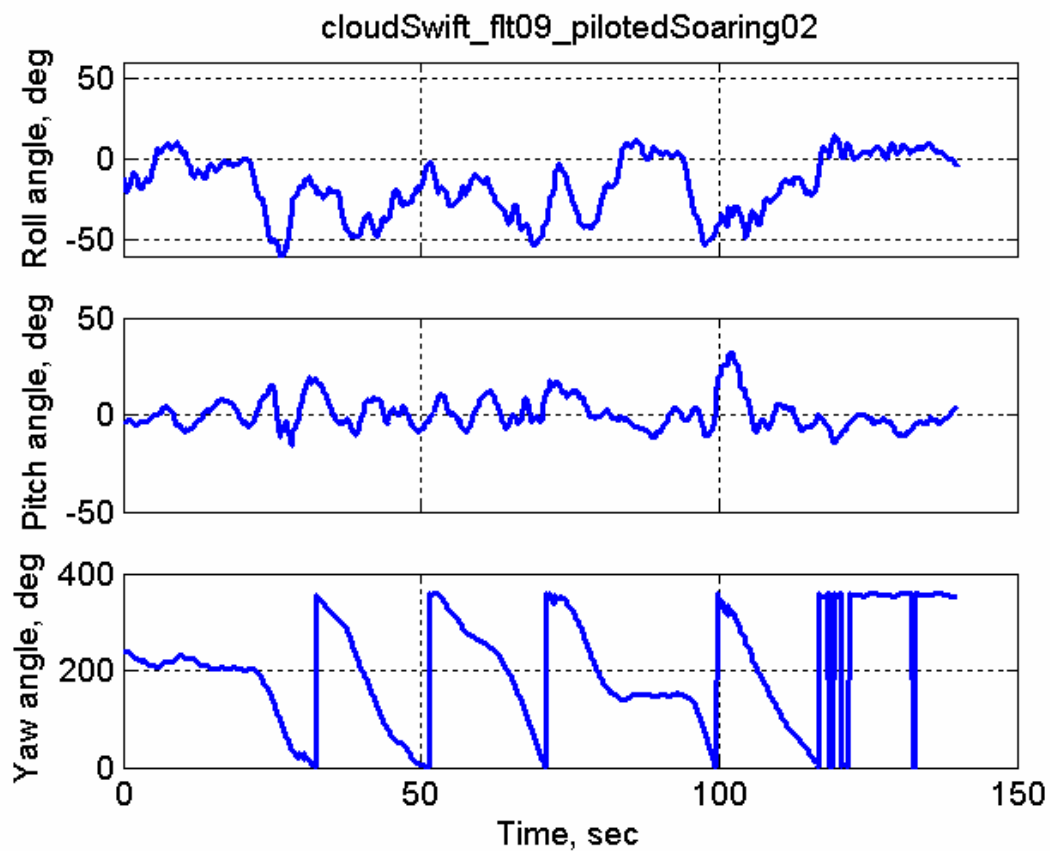
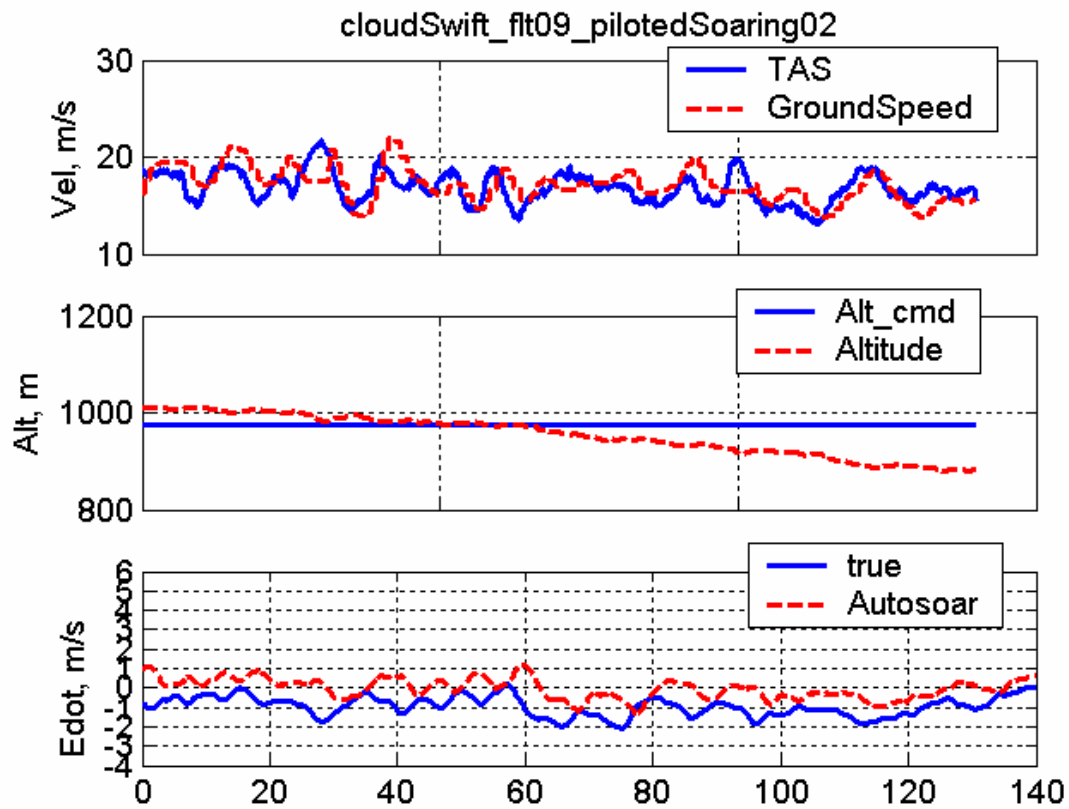


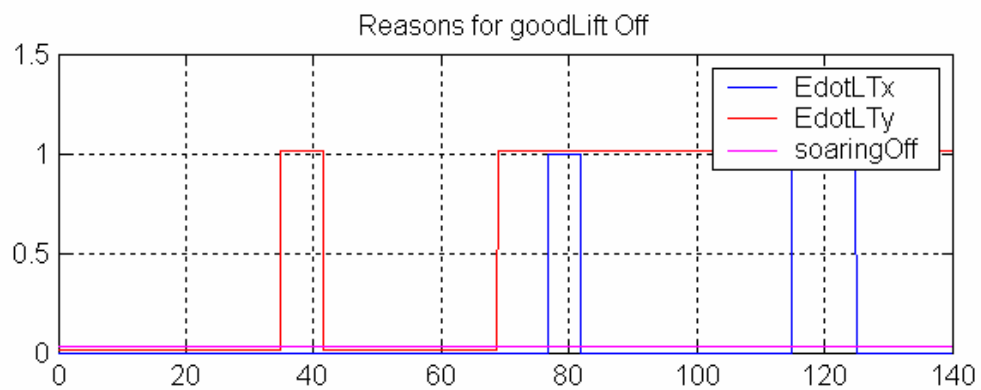
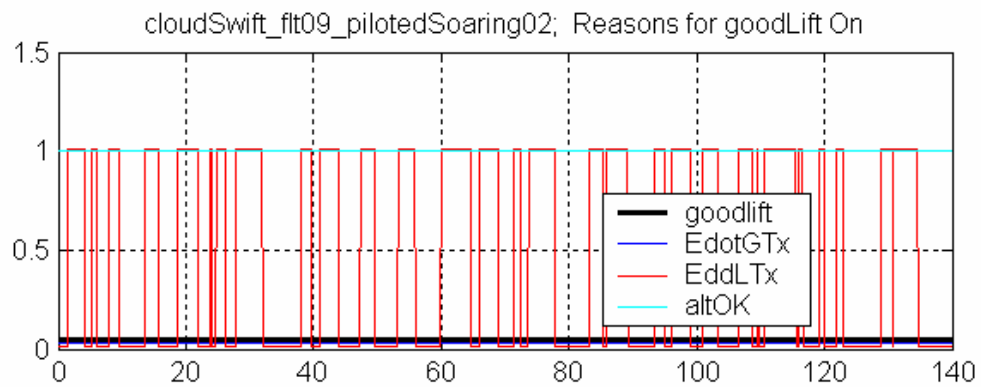
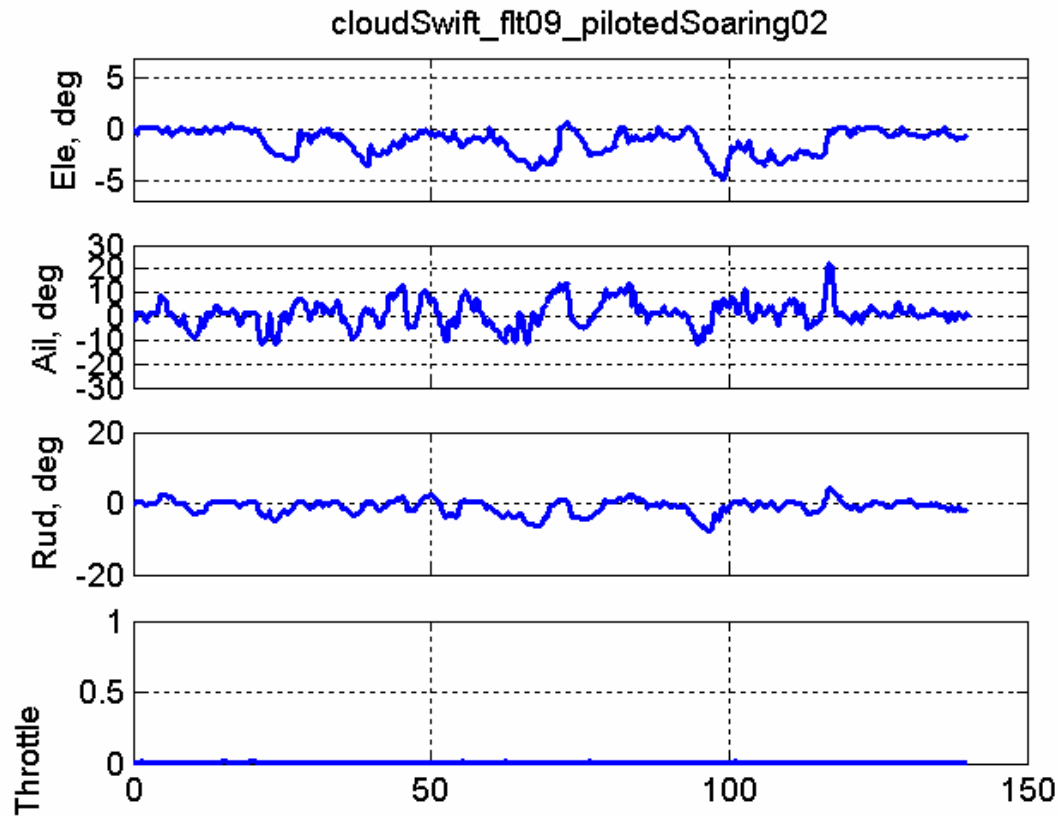


Flight 9, piloted soaring 2

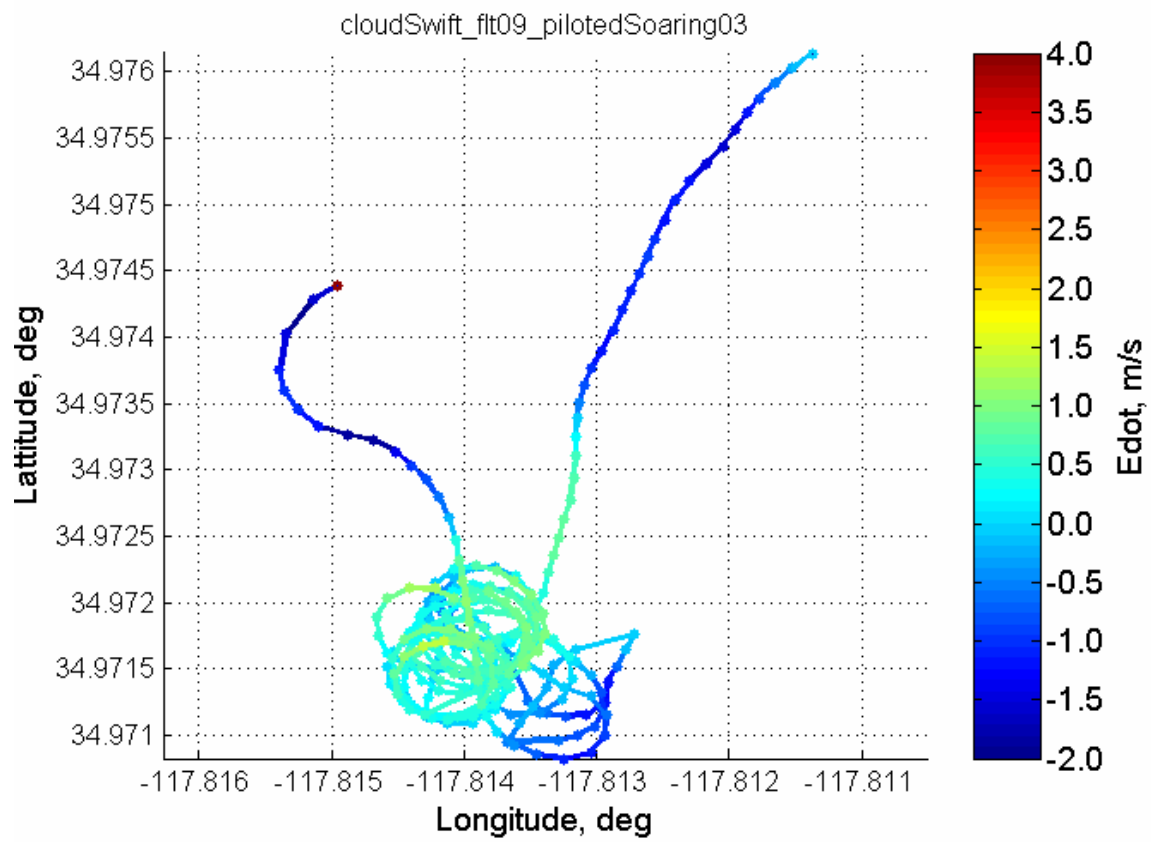


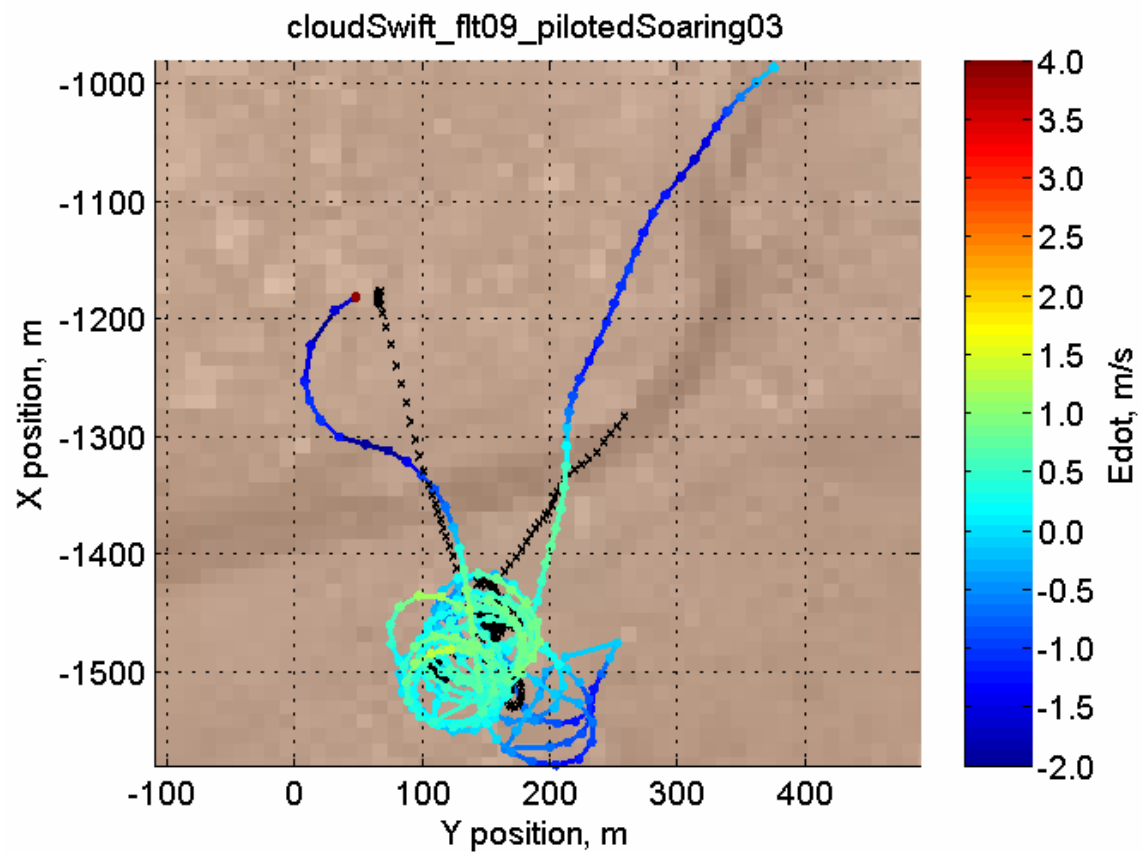
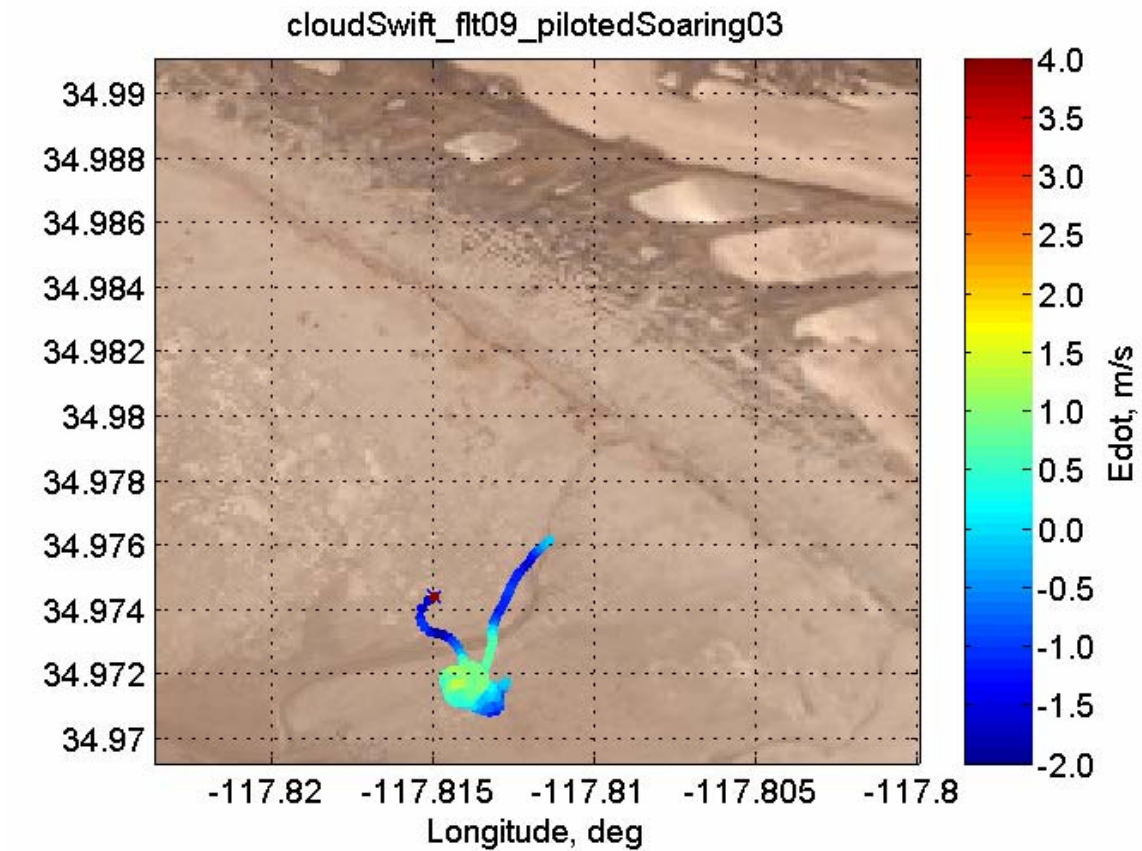


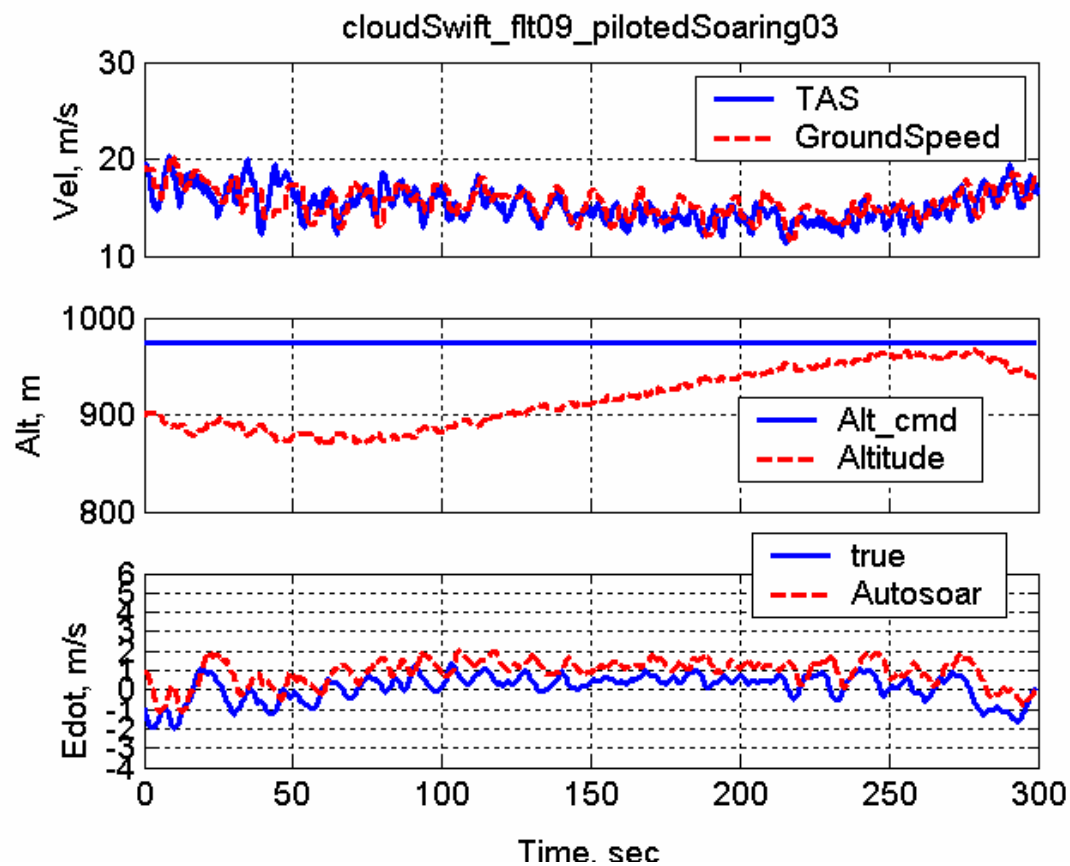
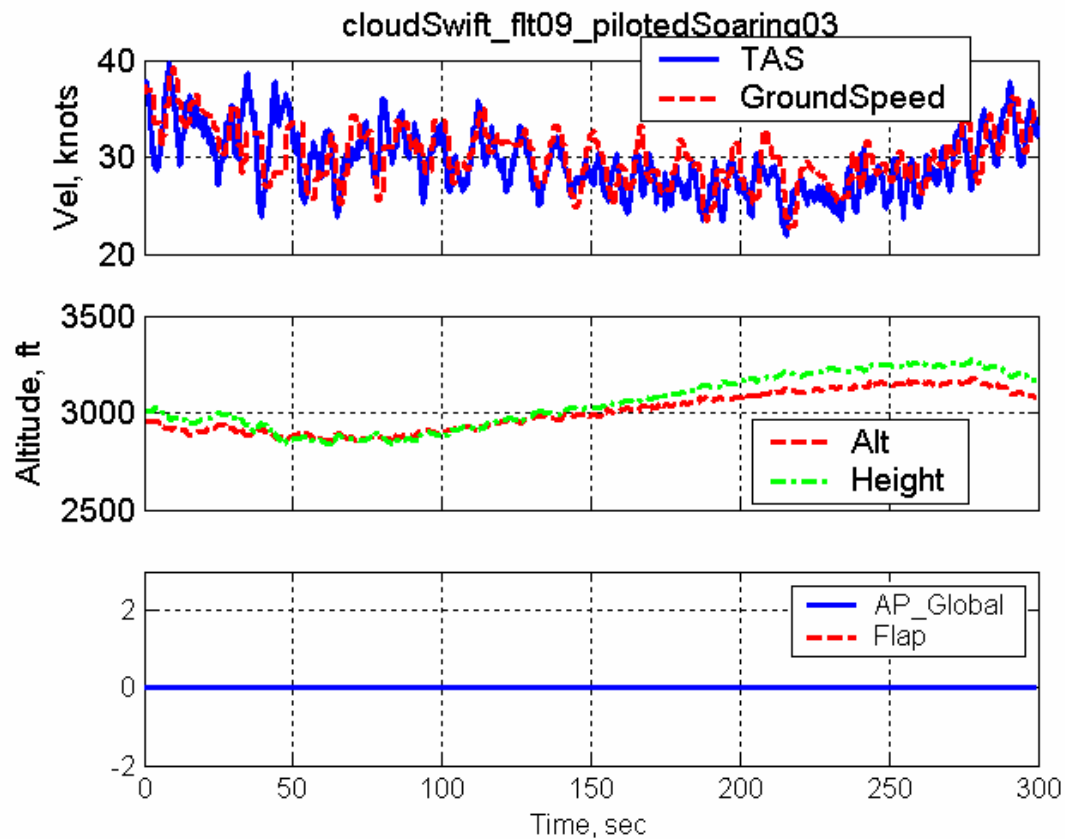


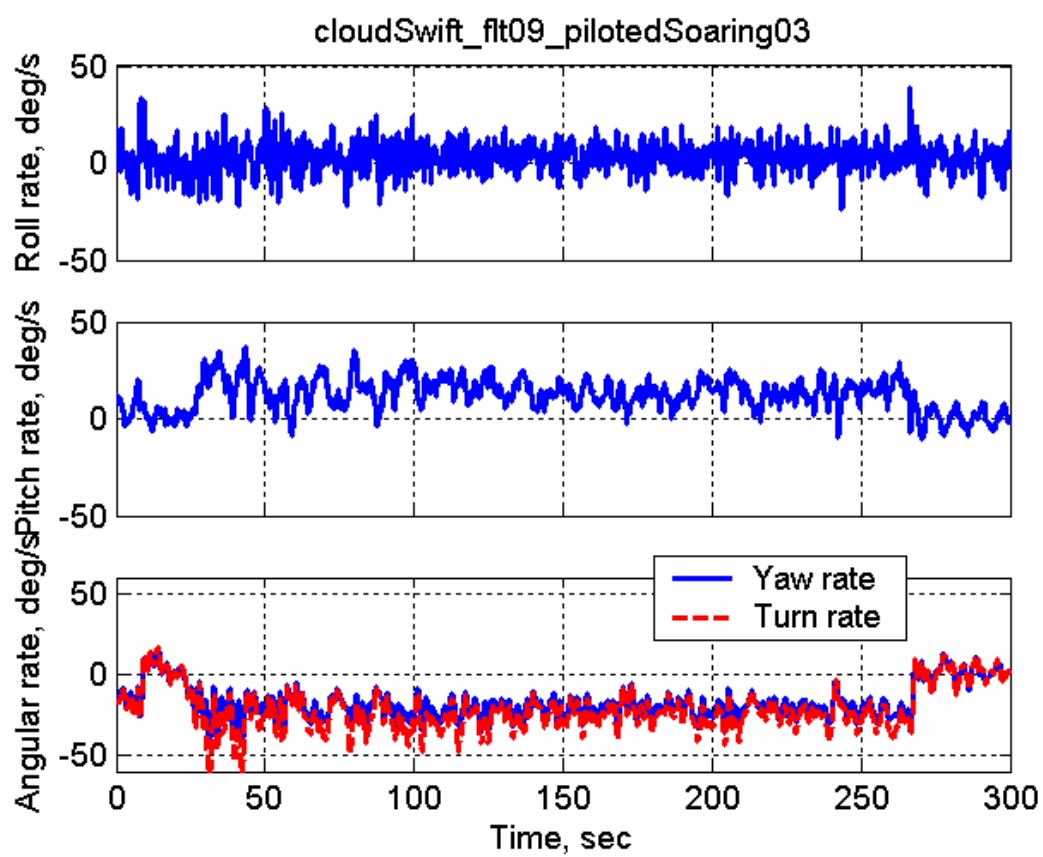


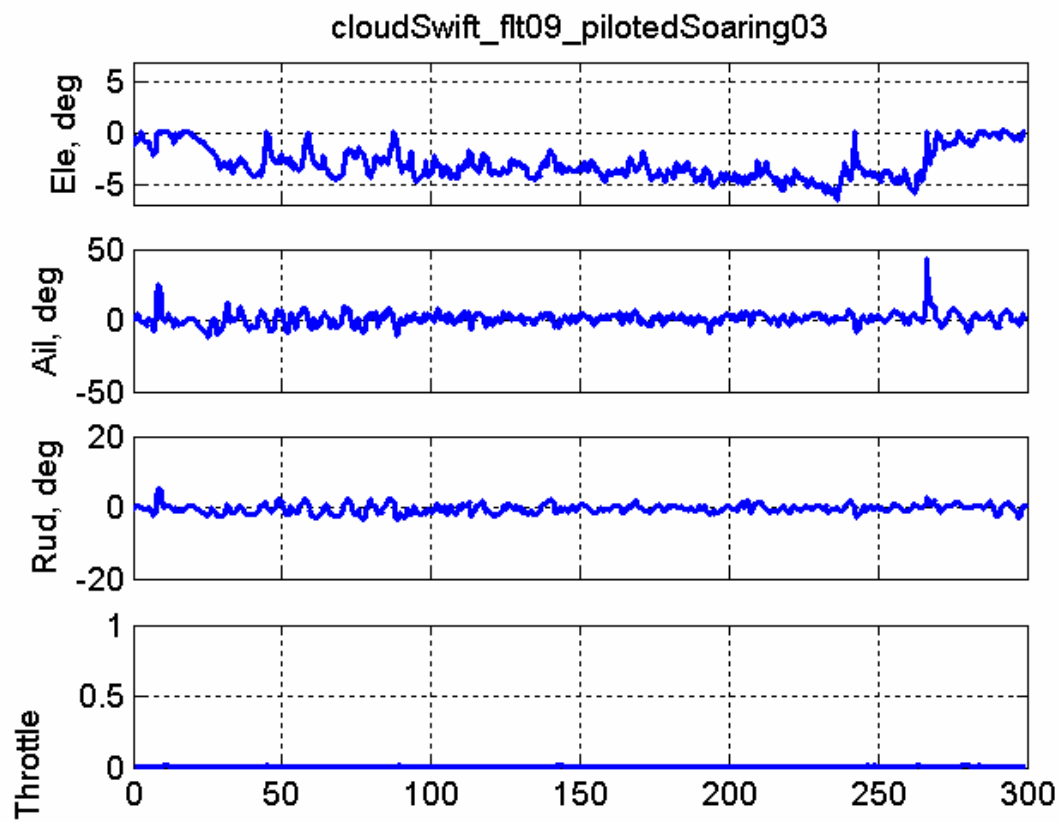
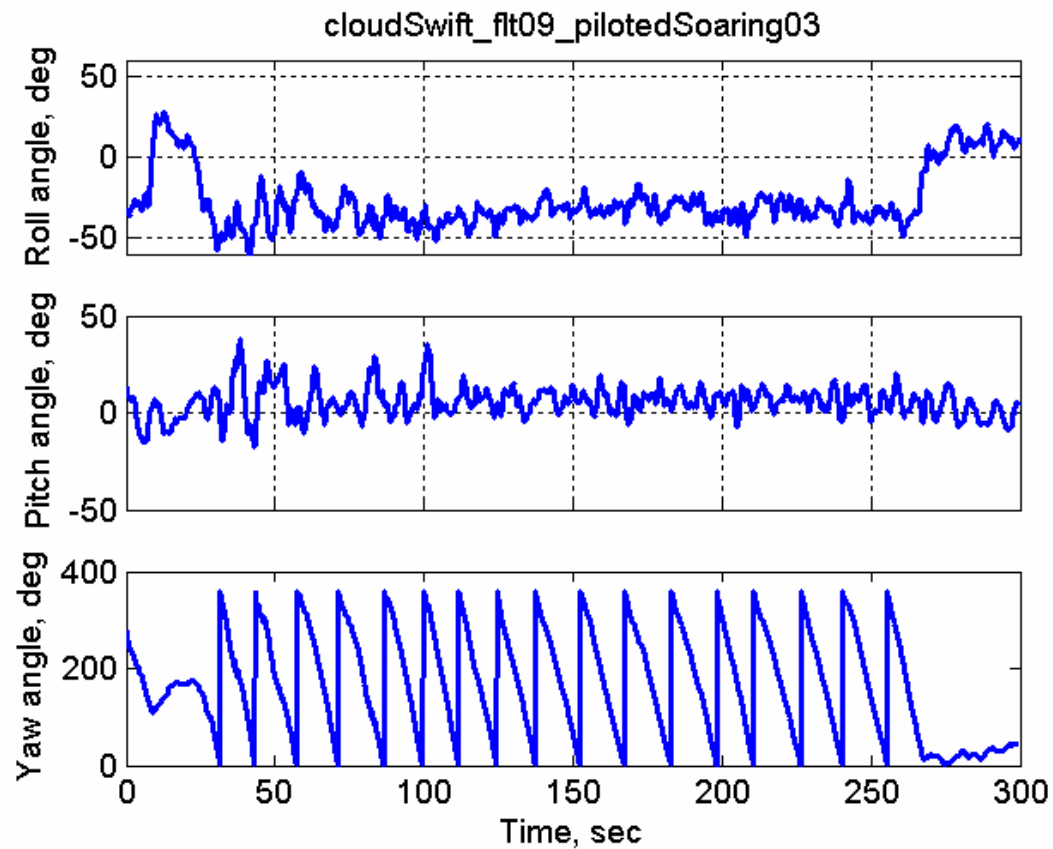
Flight 9, piloted soaring 3

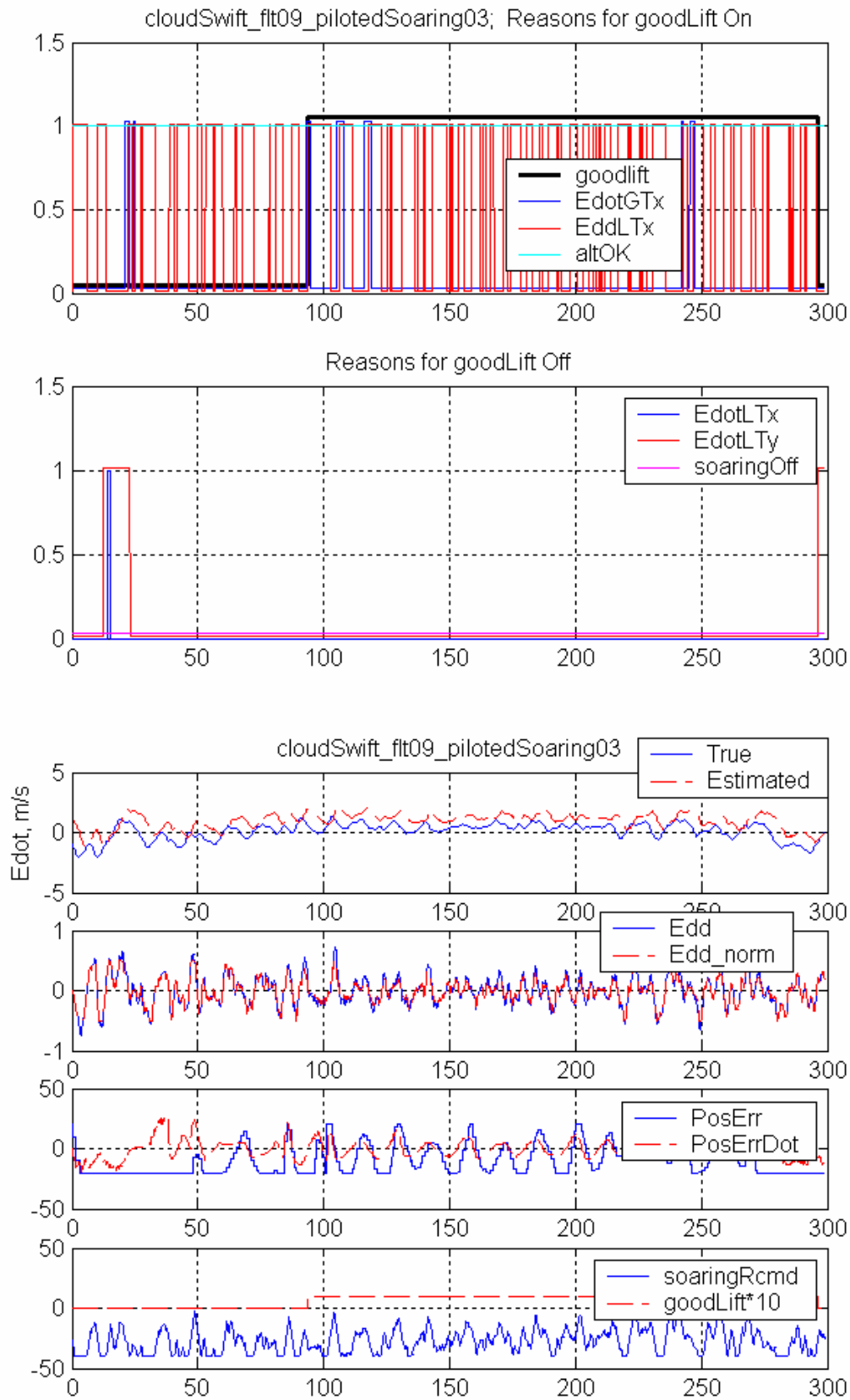


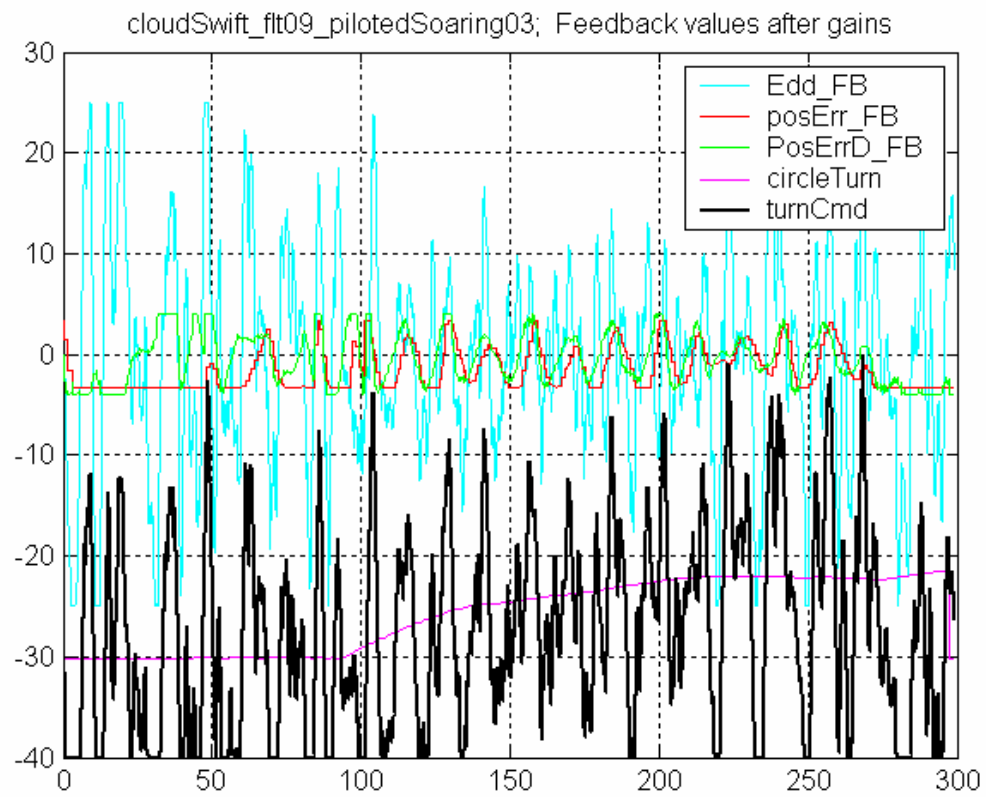




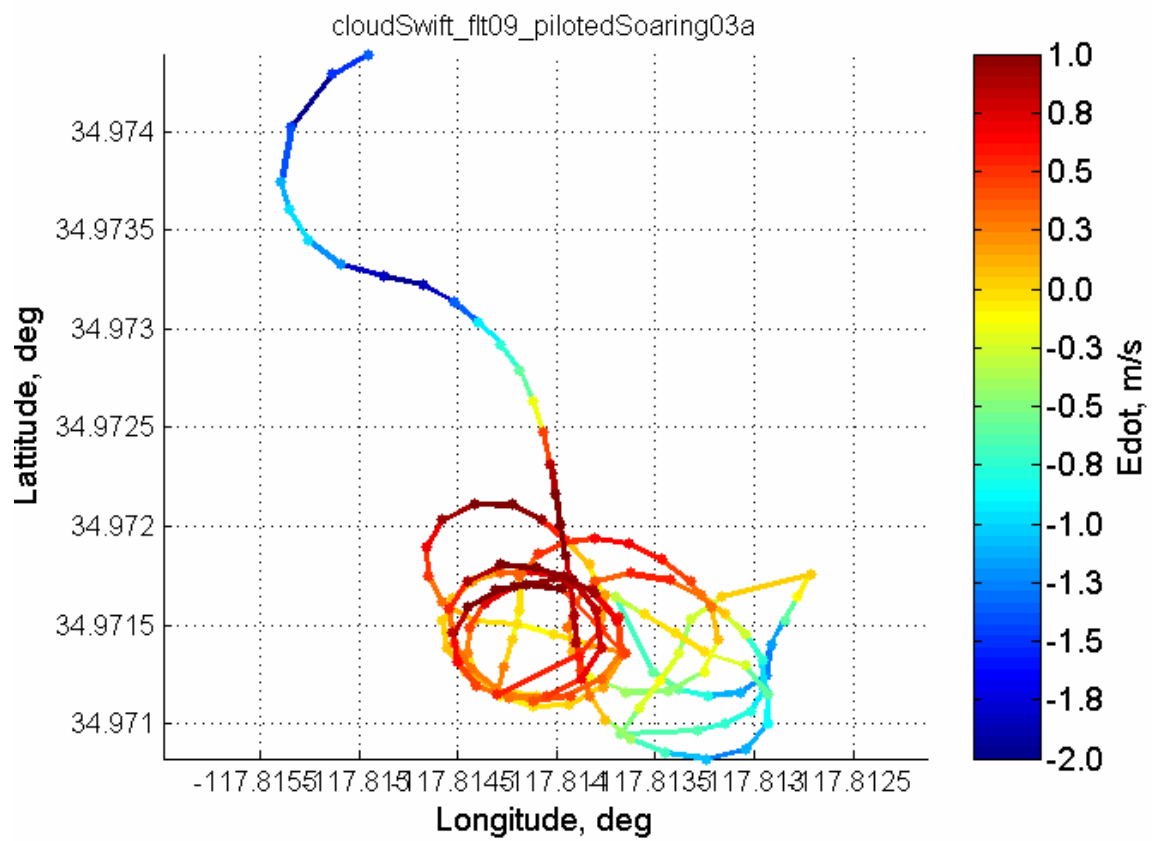


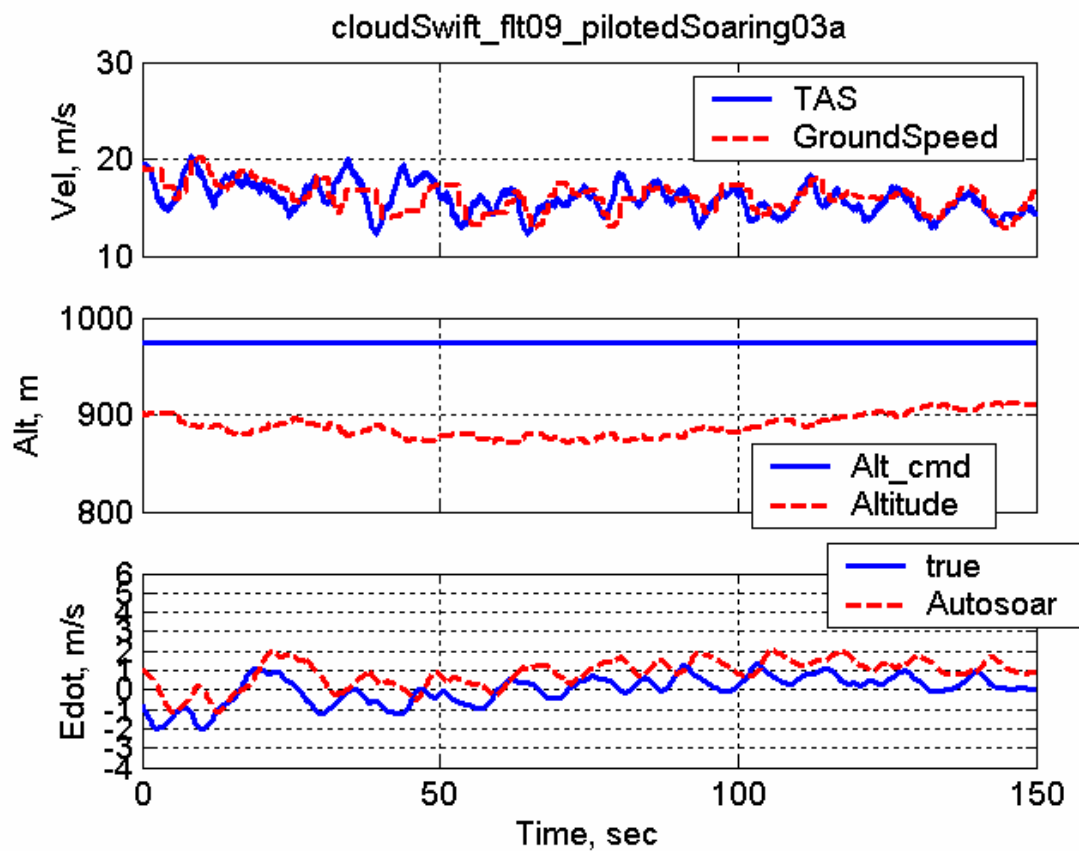
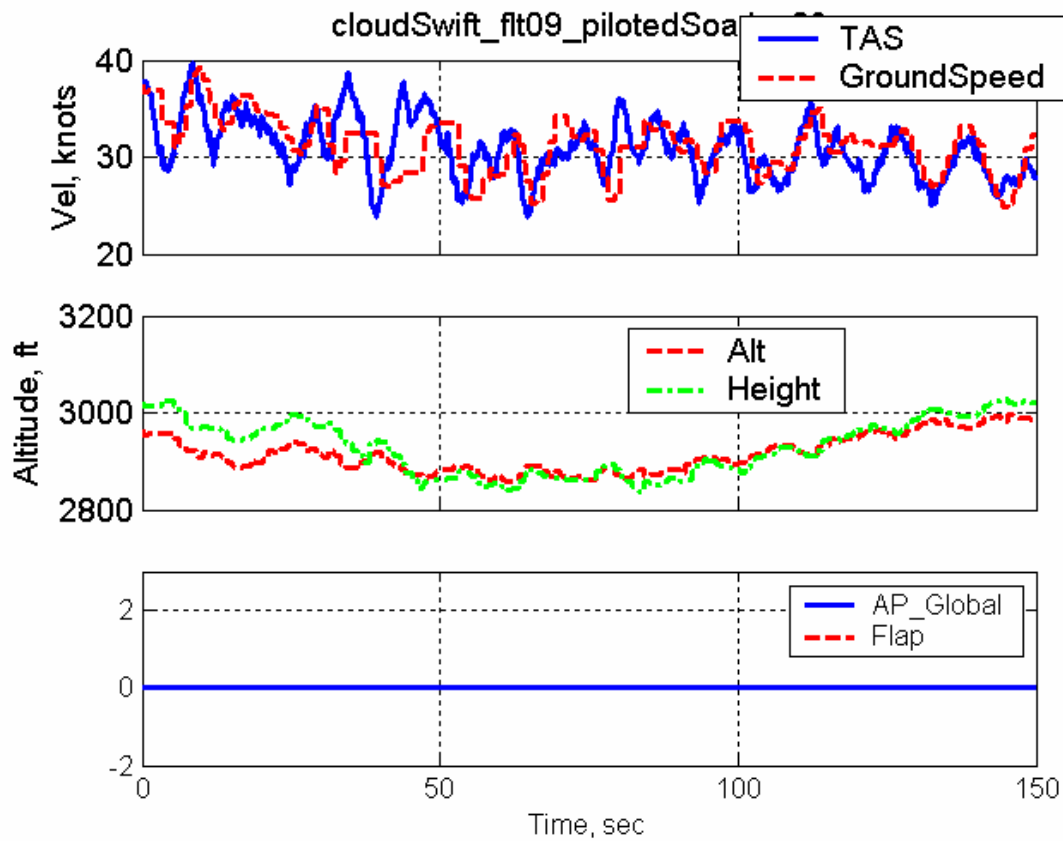




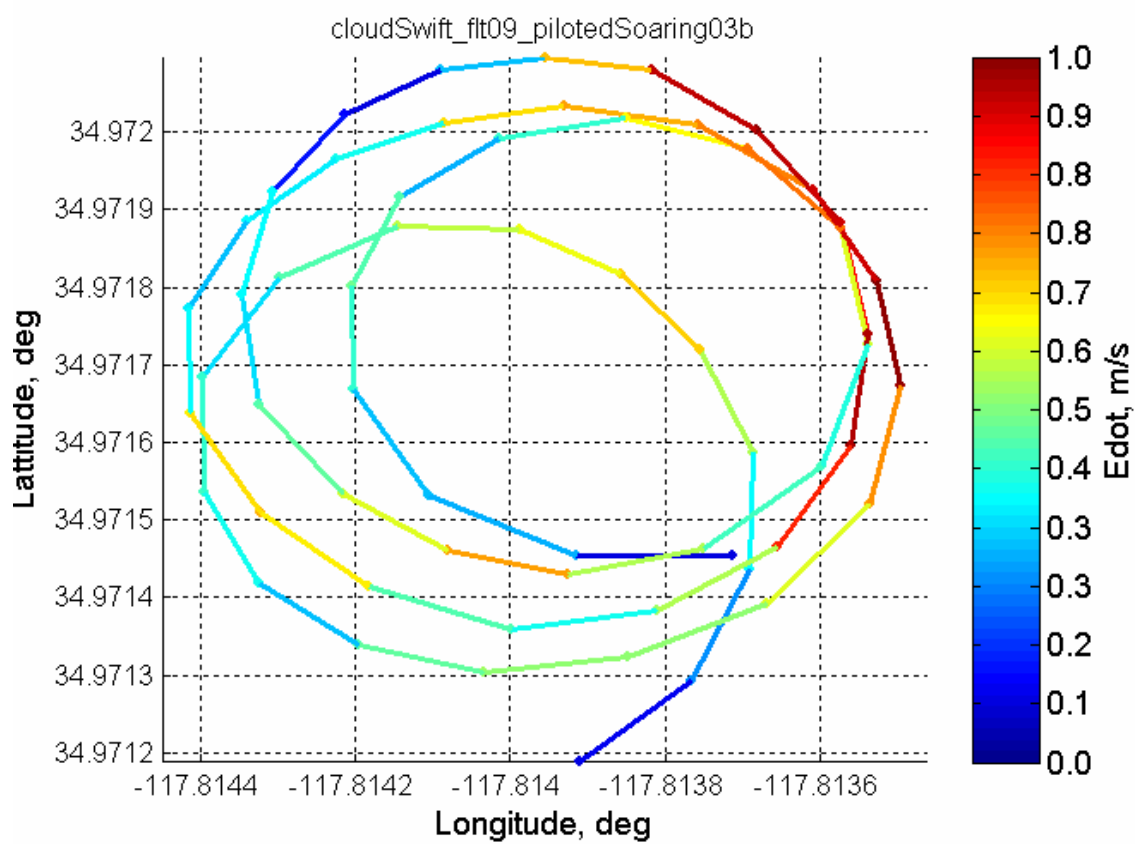


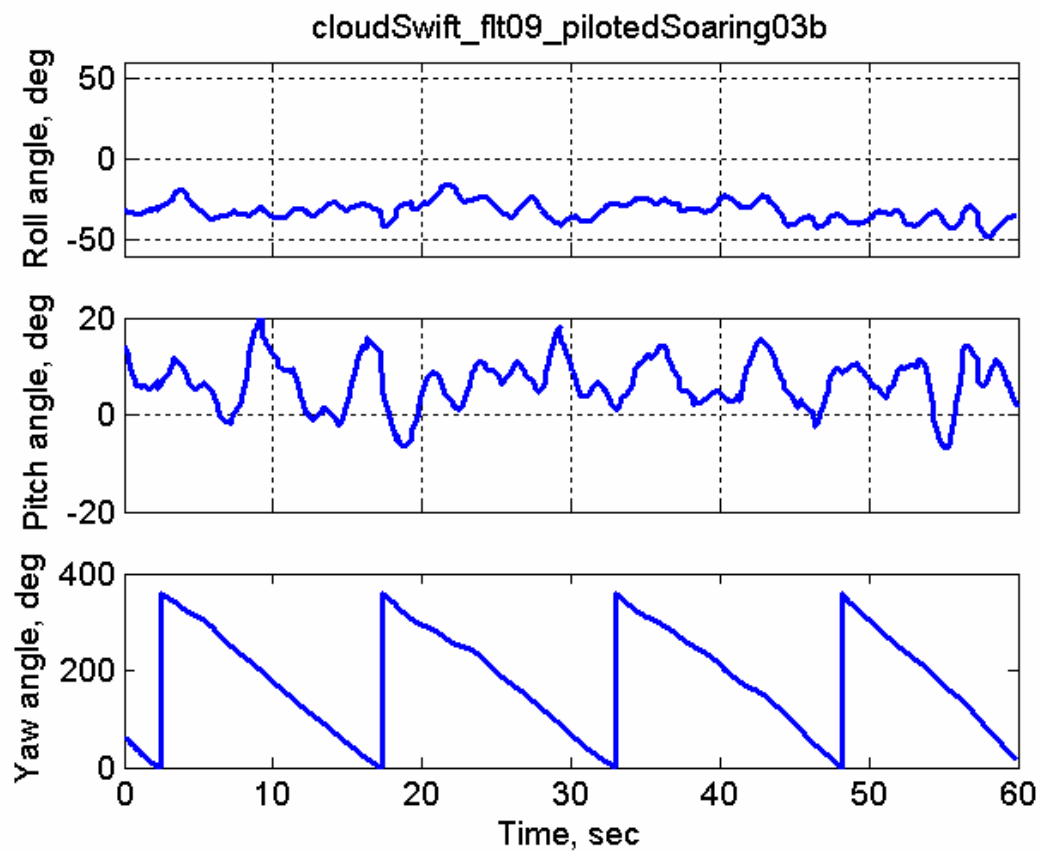
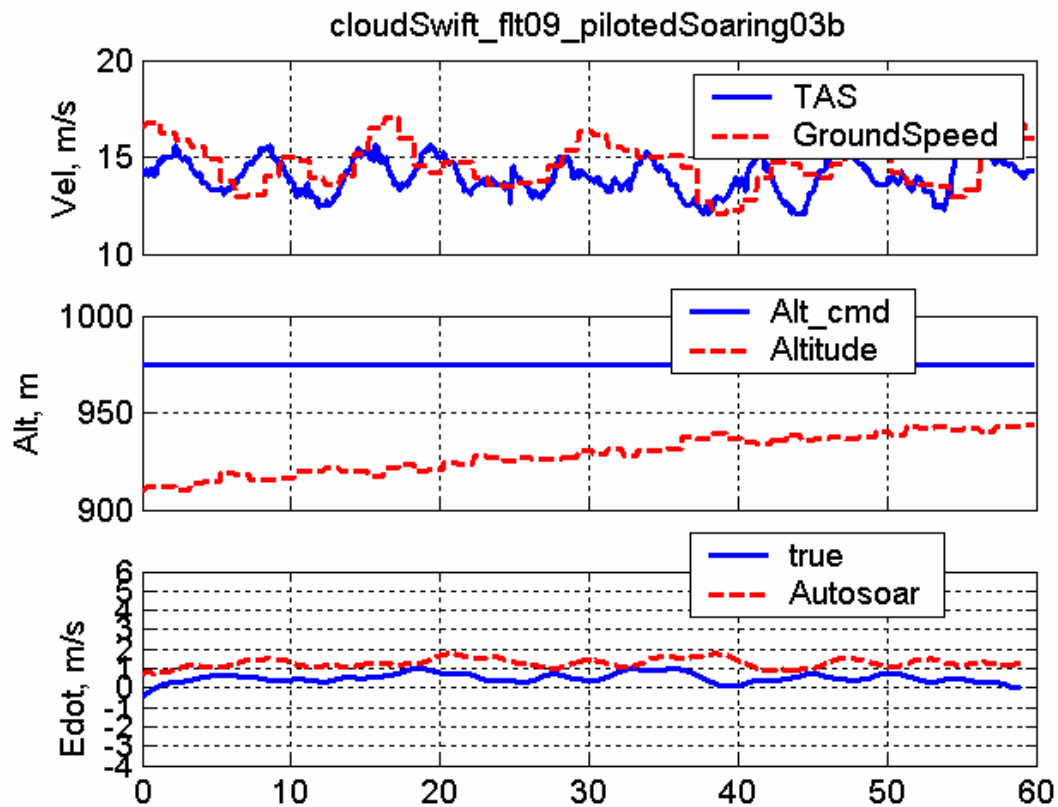
Flight 9, piloted soaring 3a



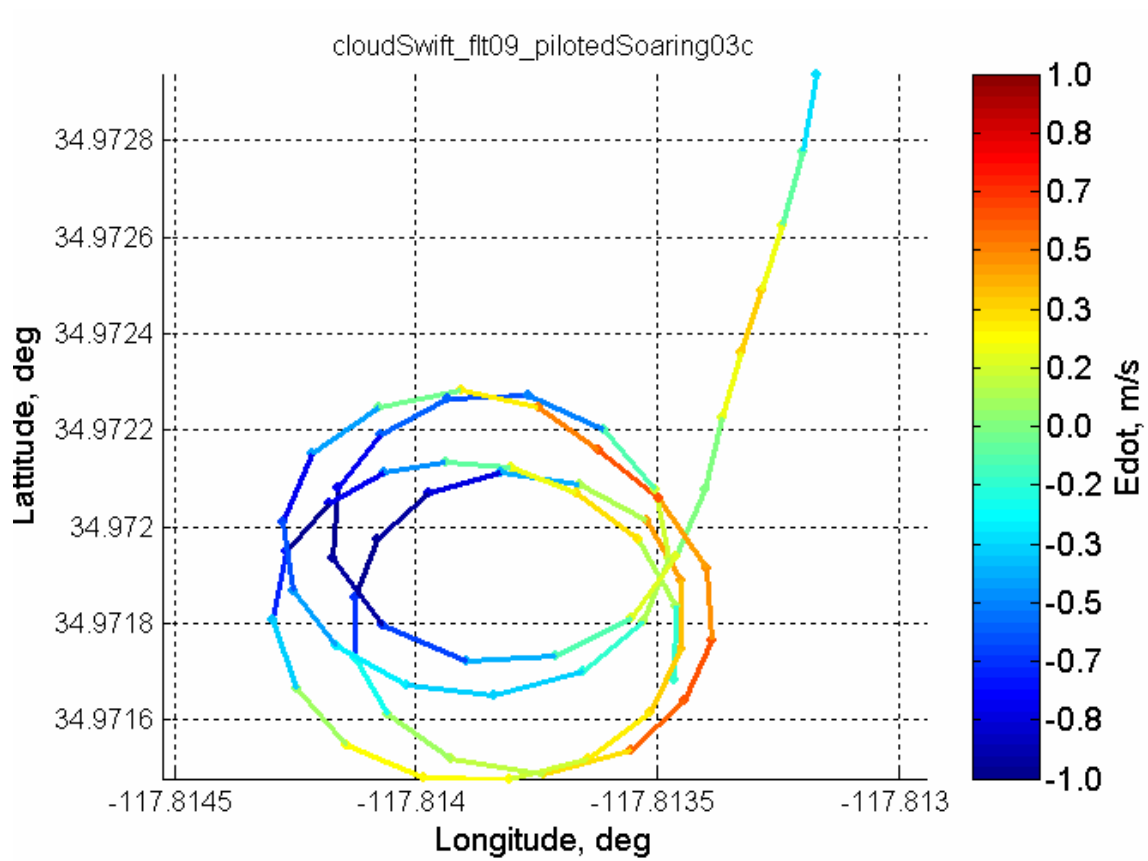


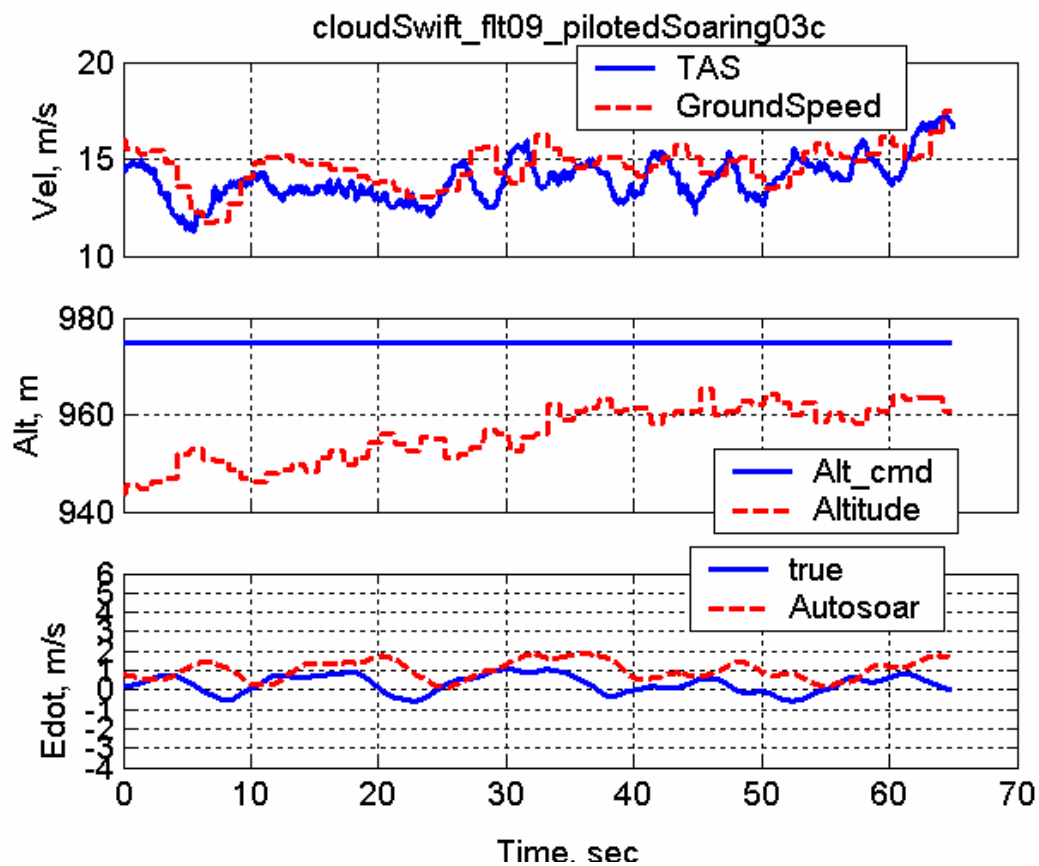
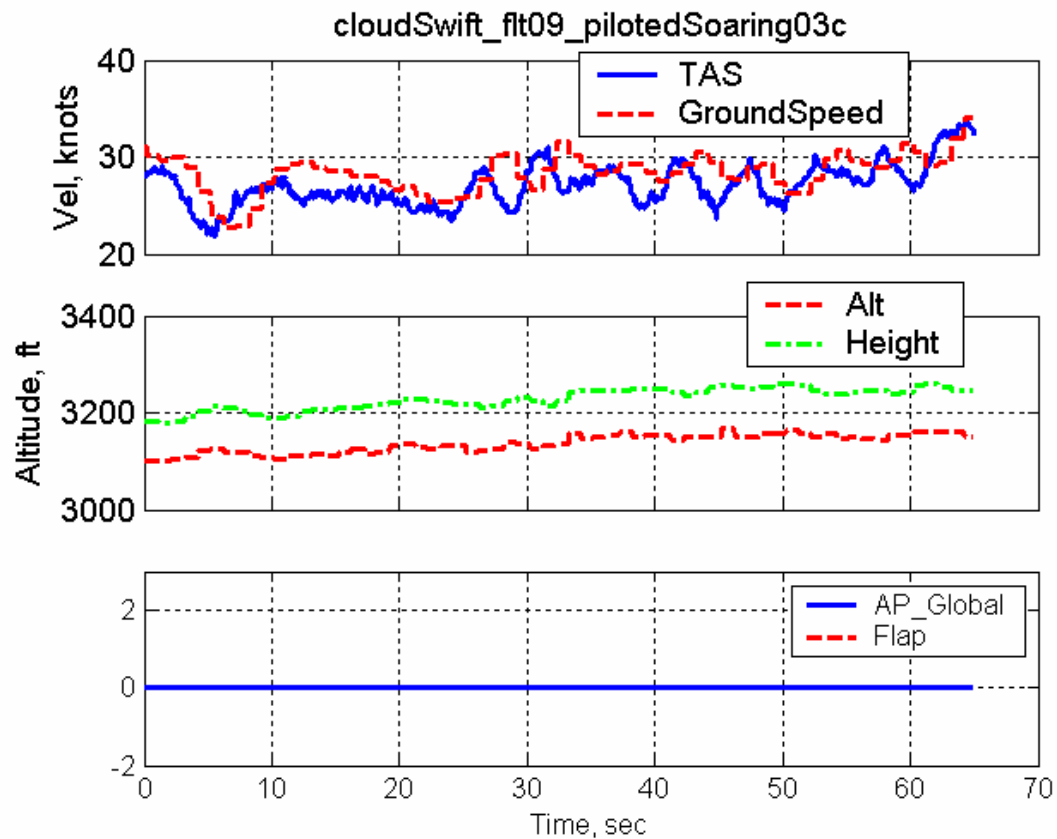
Flight 9, piloted soaring 3b



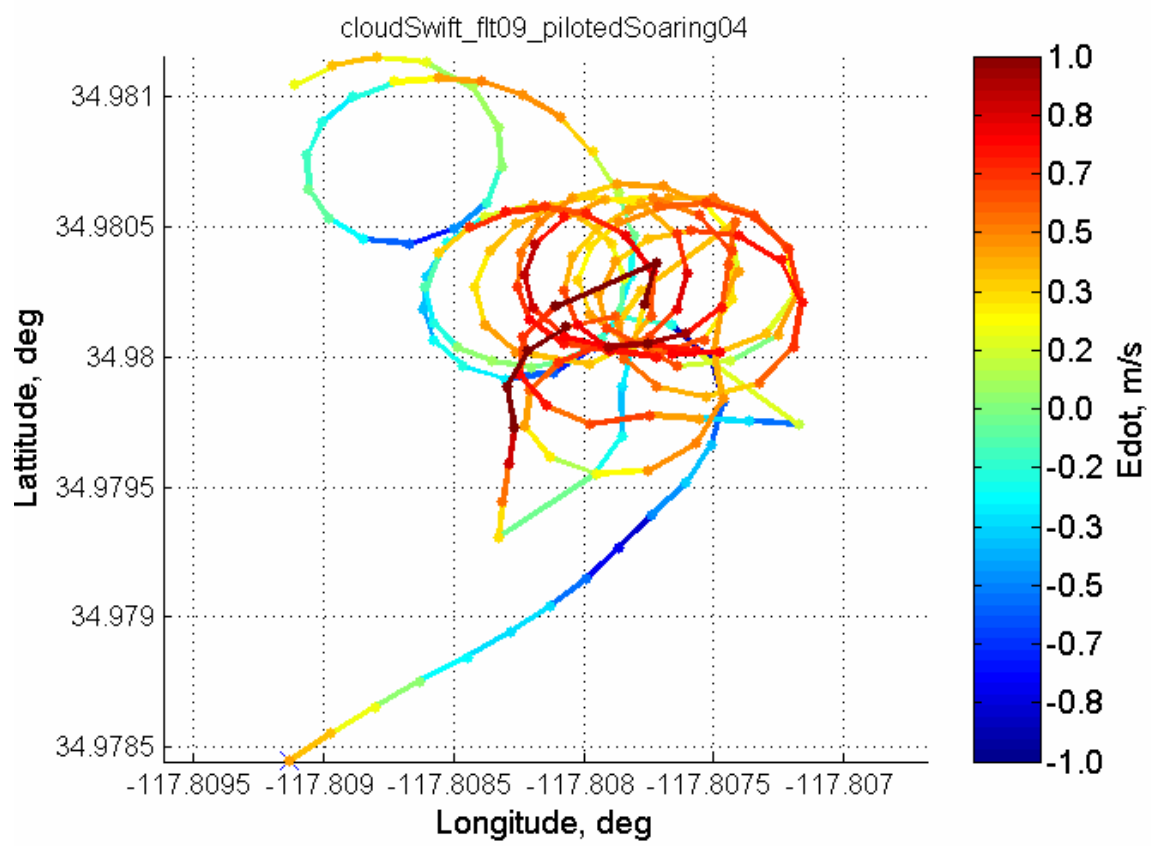


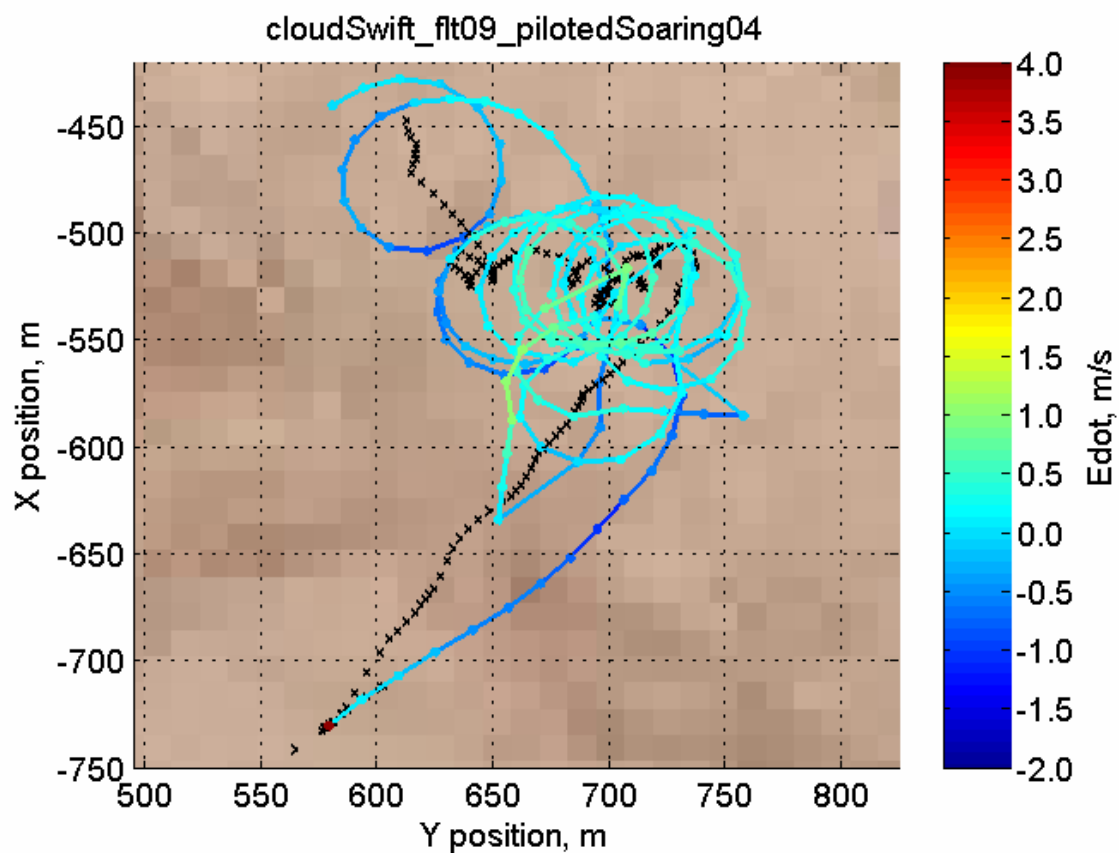
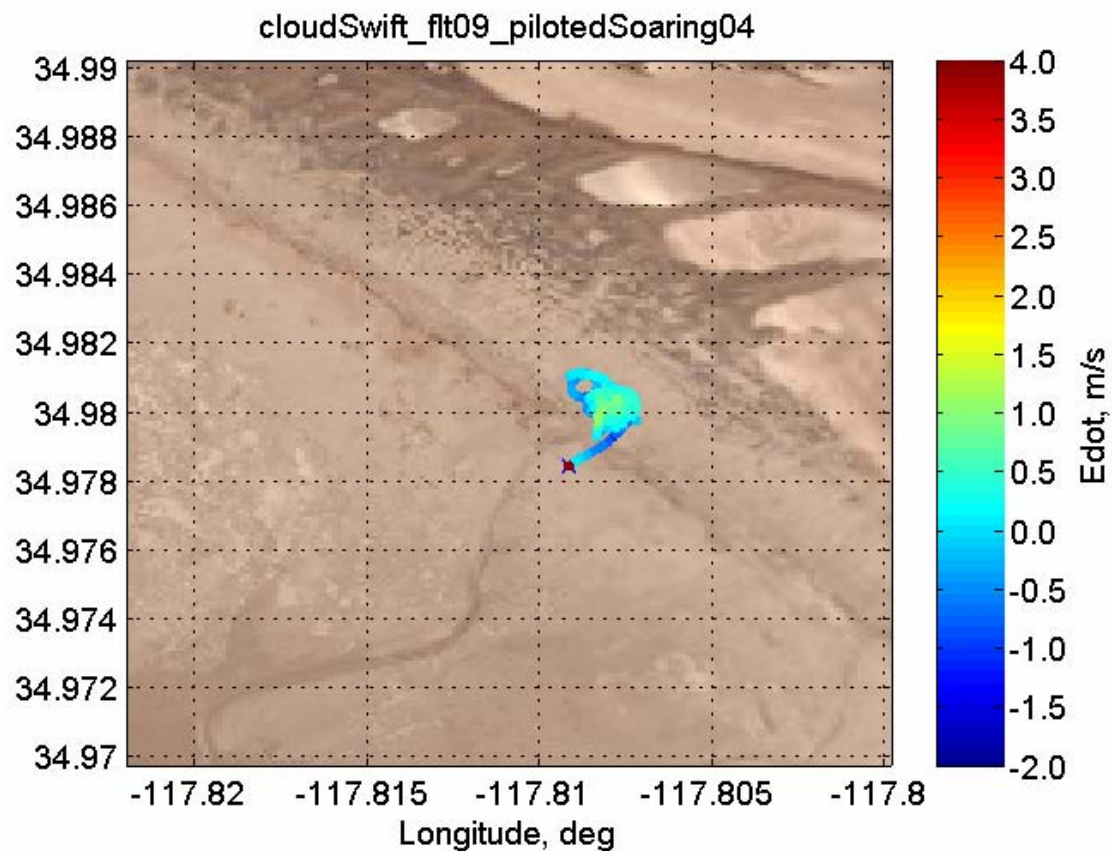
Flight 9, piloted soaring 3c

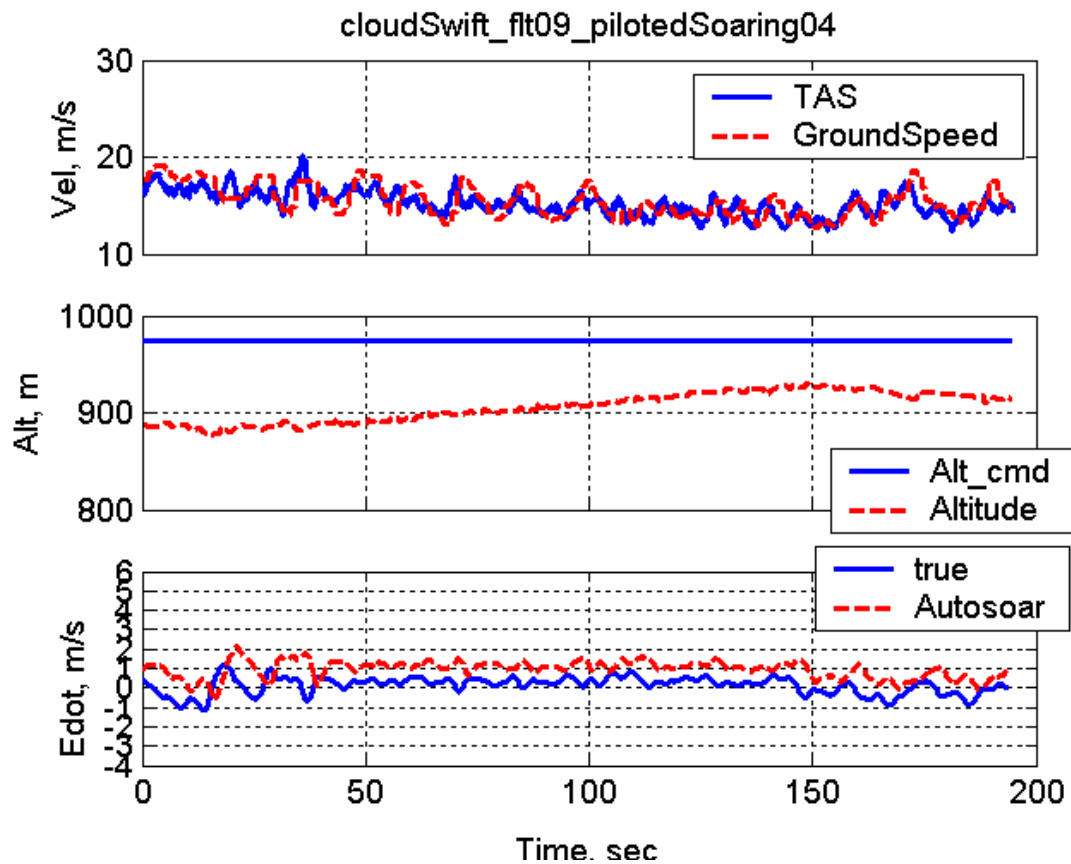
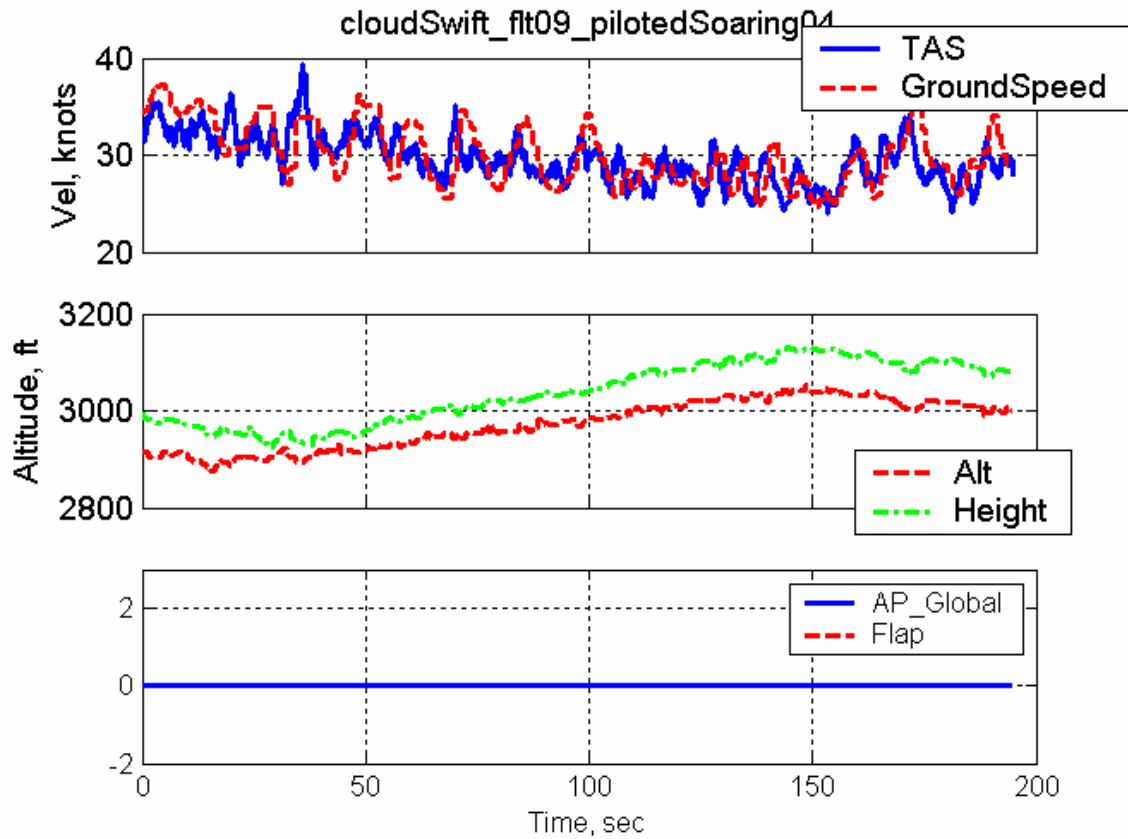


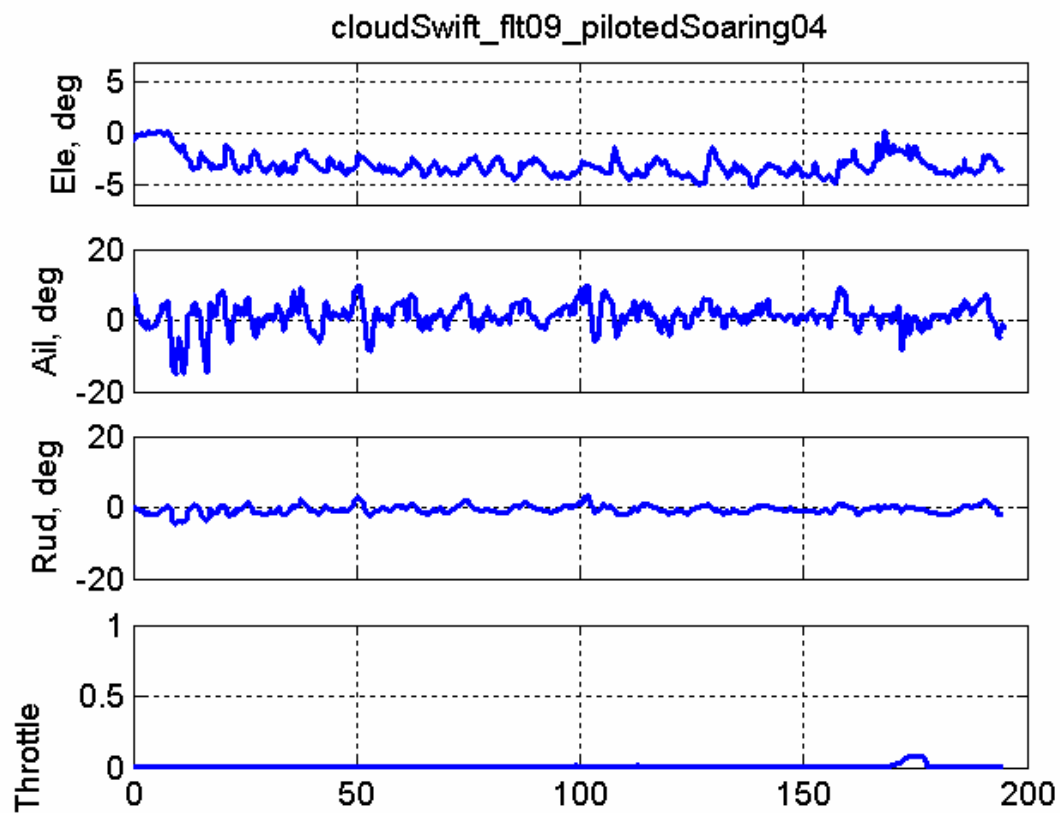
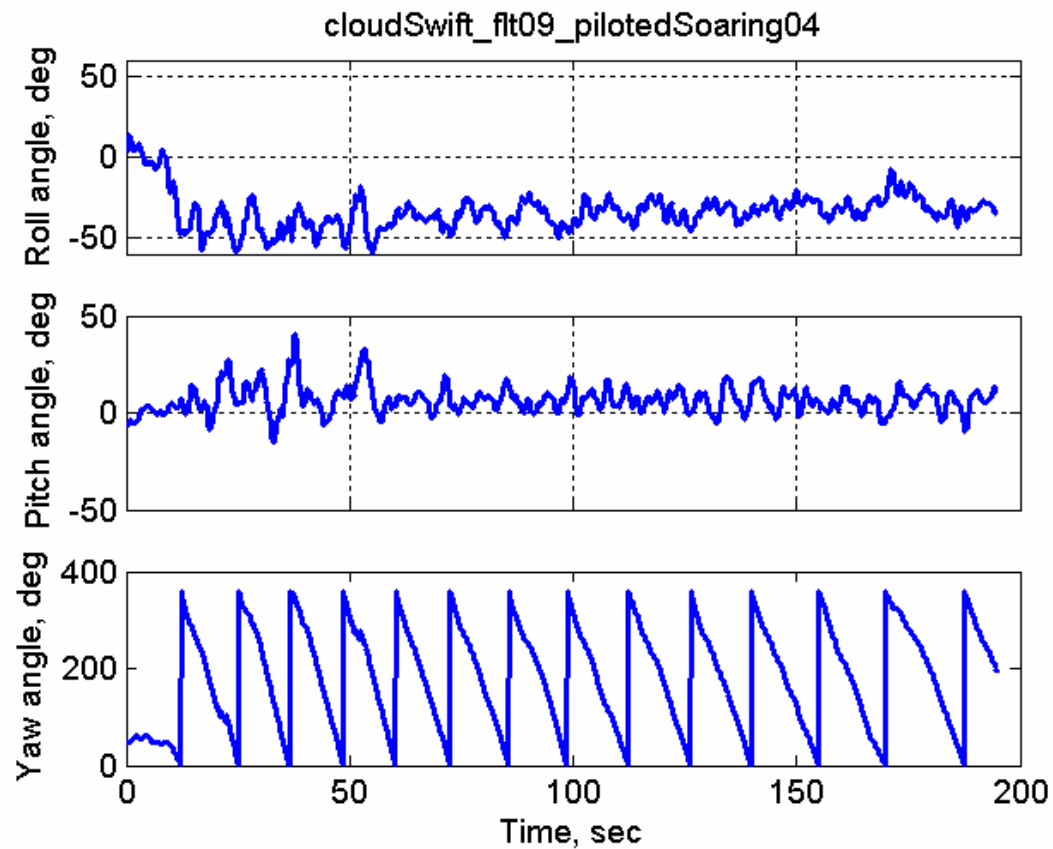


Flight 9, piloted soaring 4

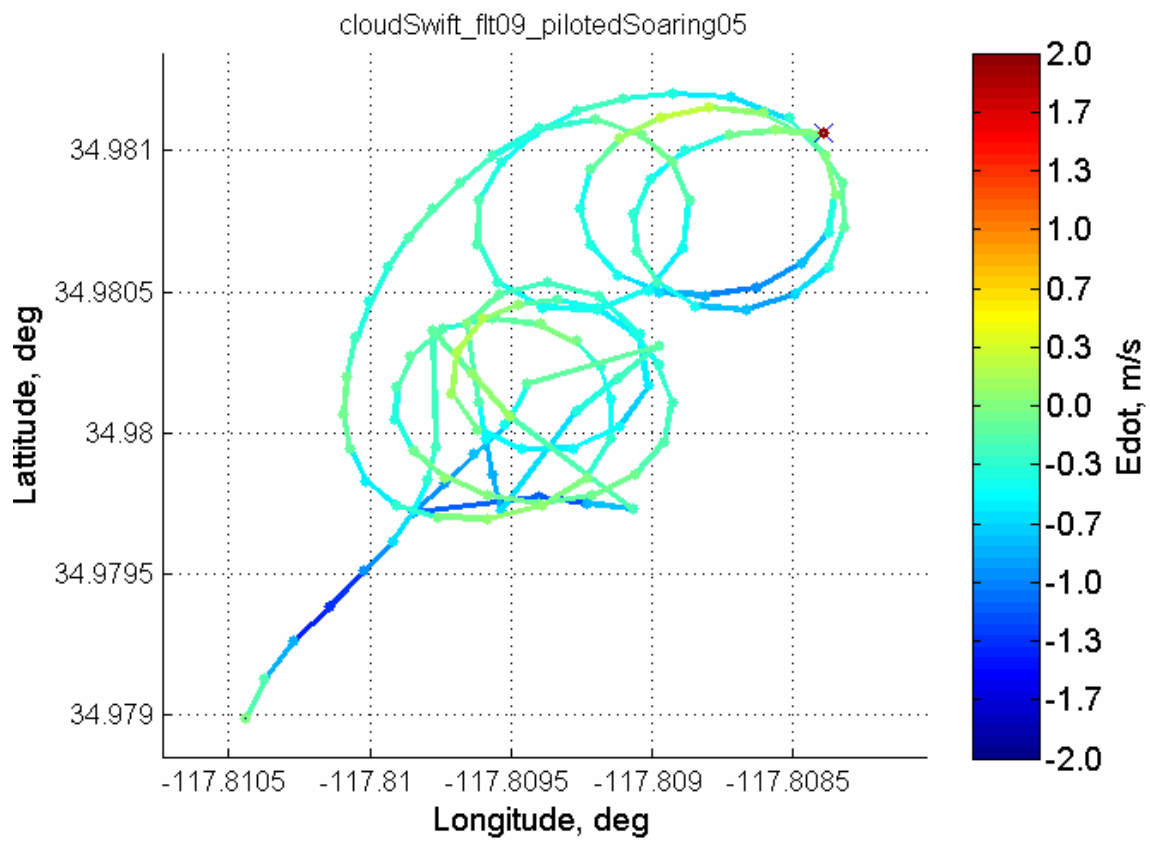


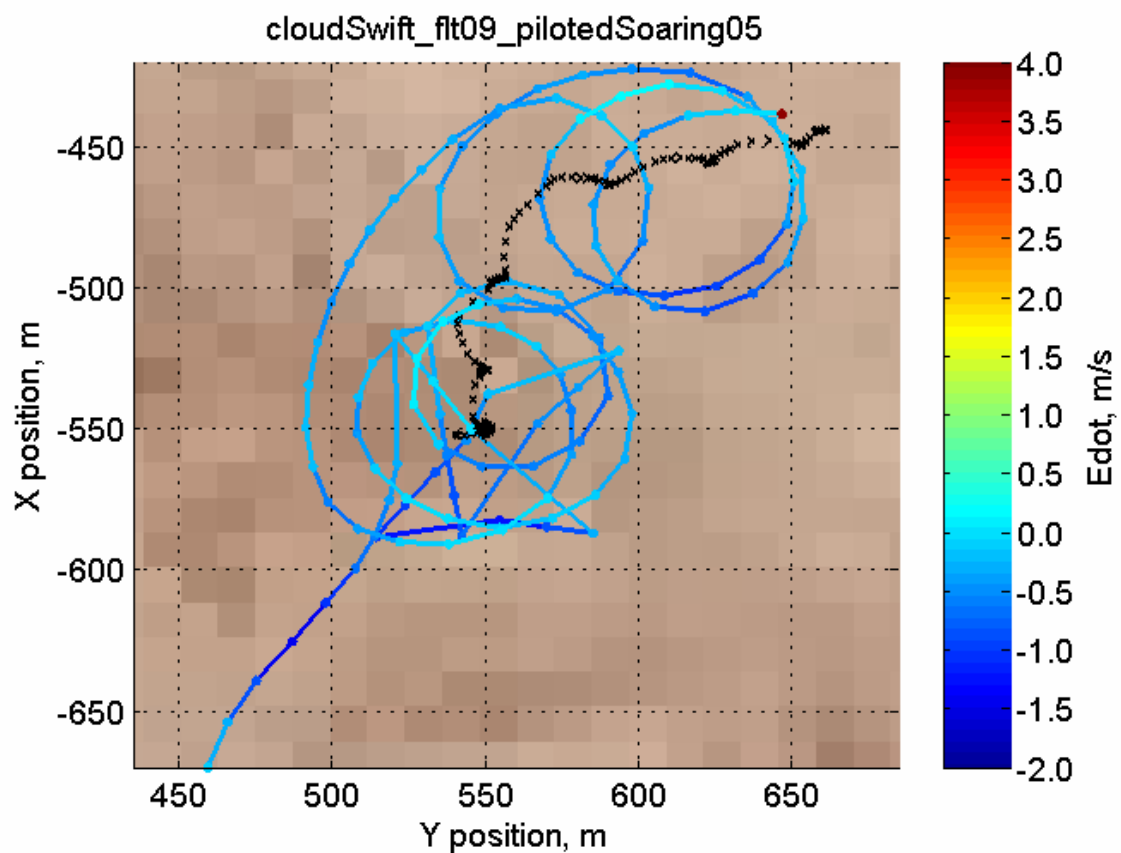
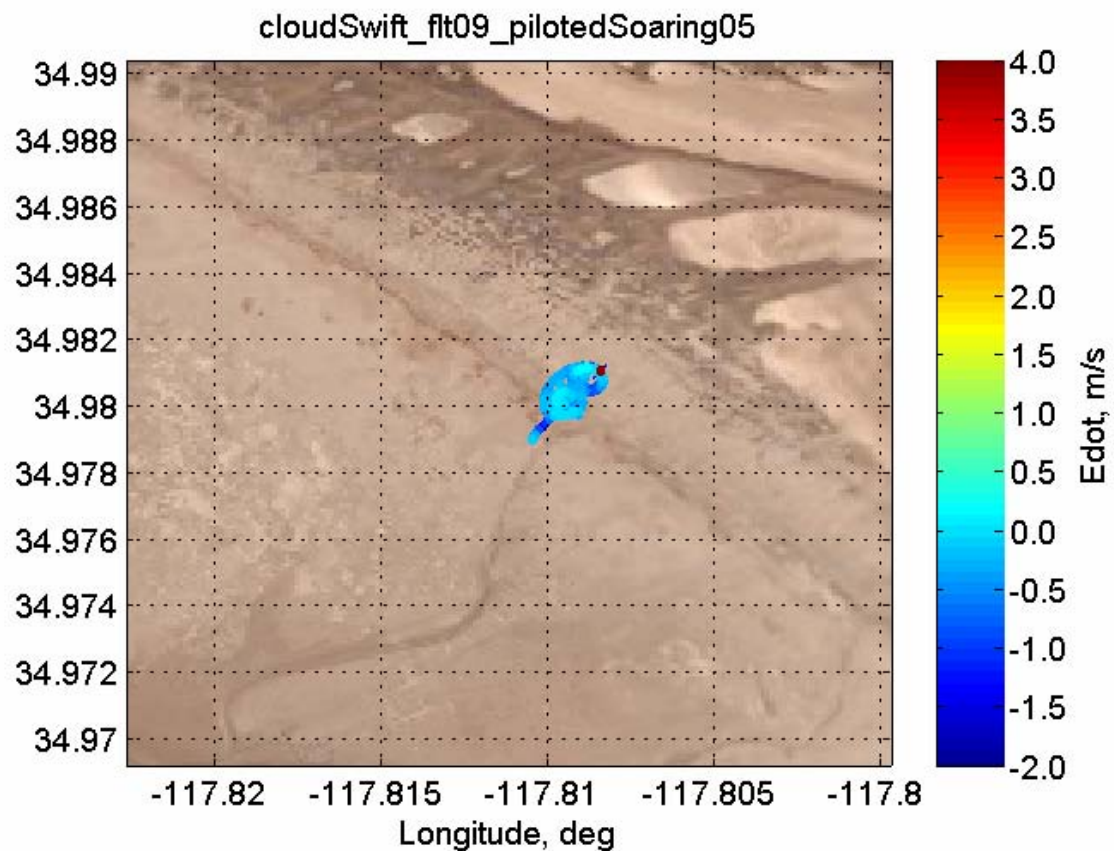


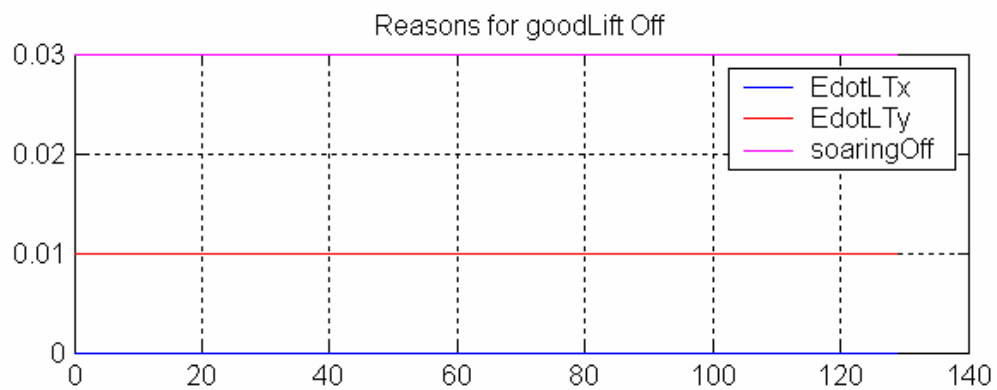
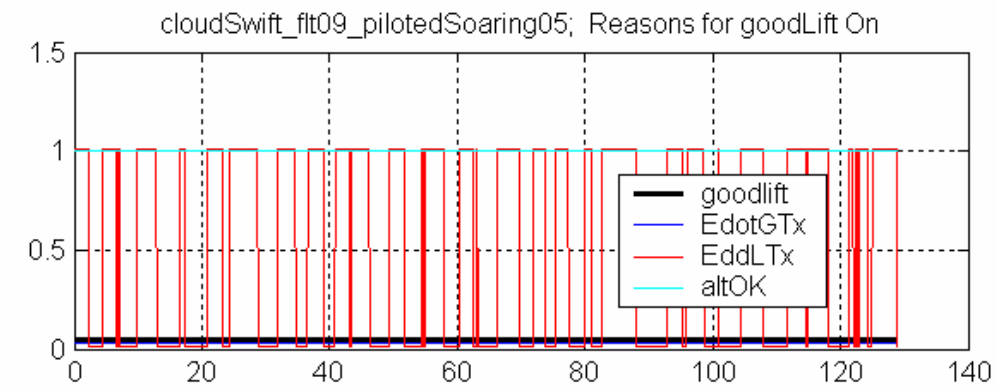
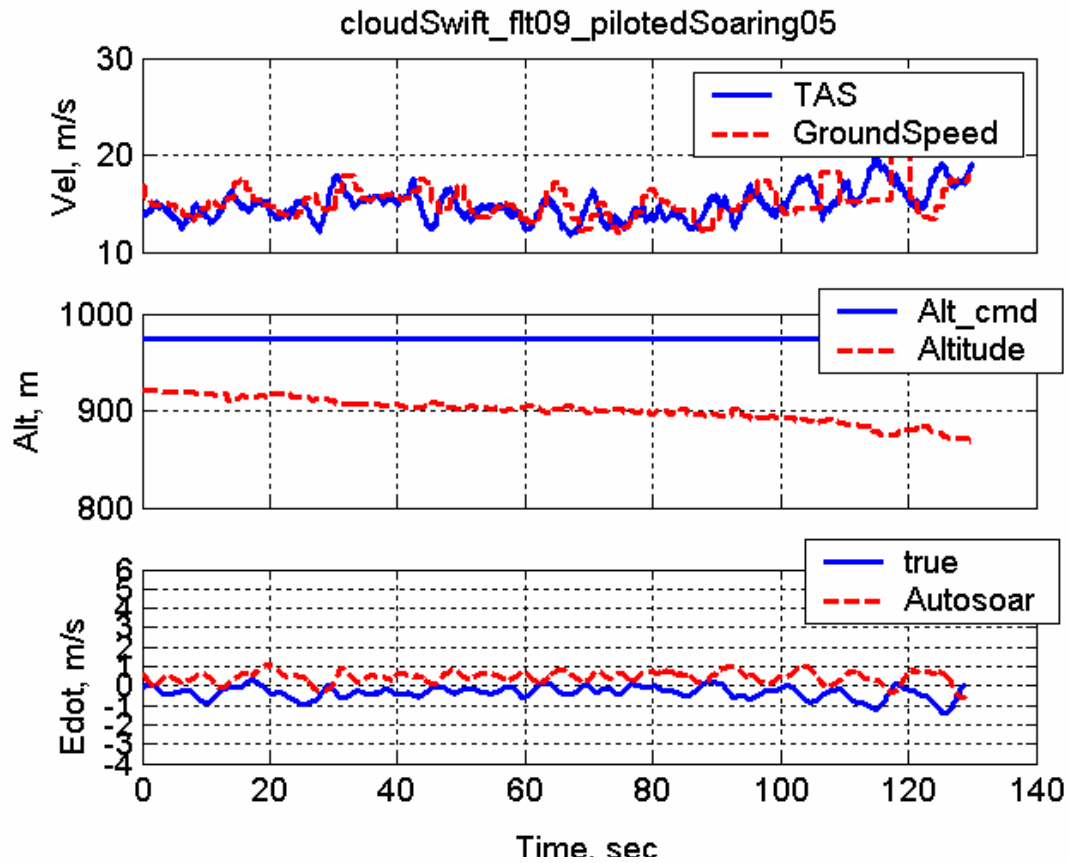




Flight 9, piloted soaring 5

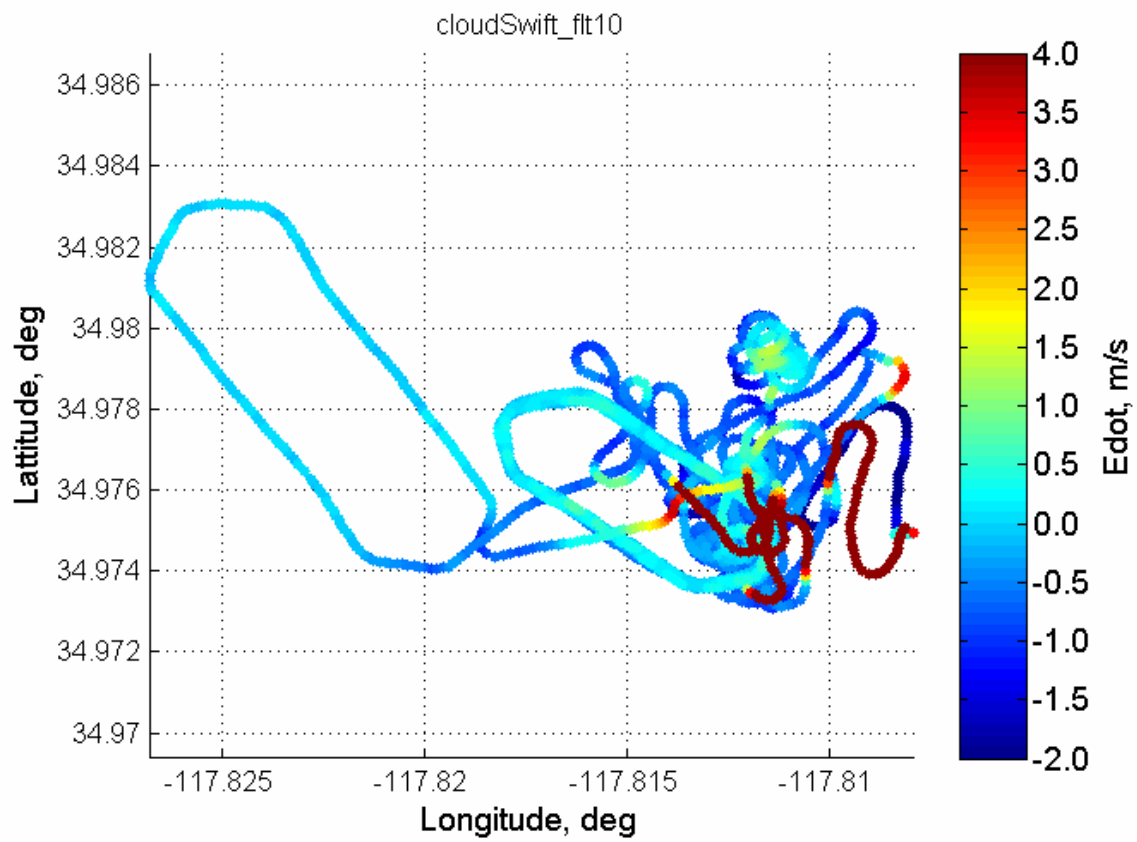


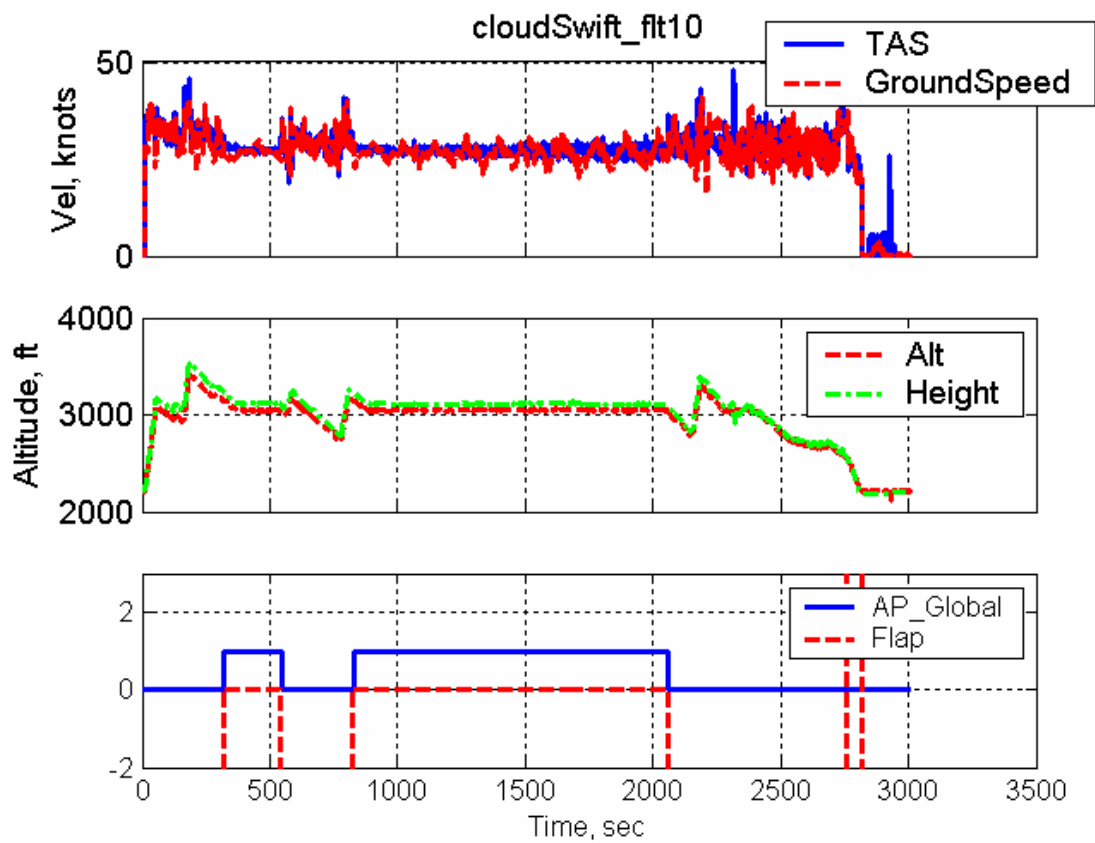
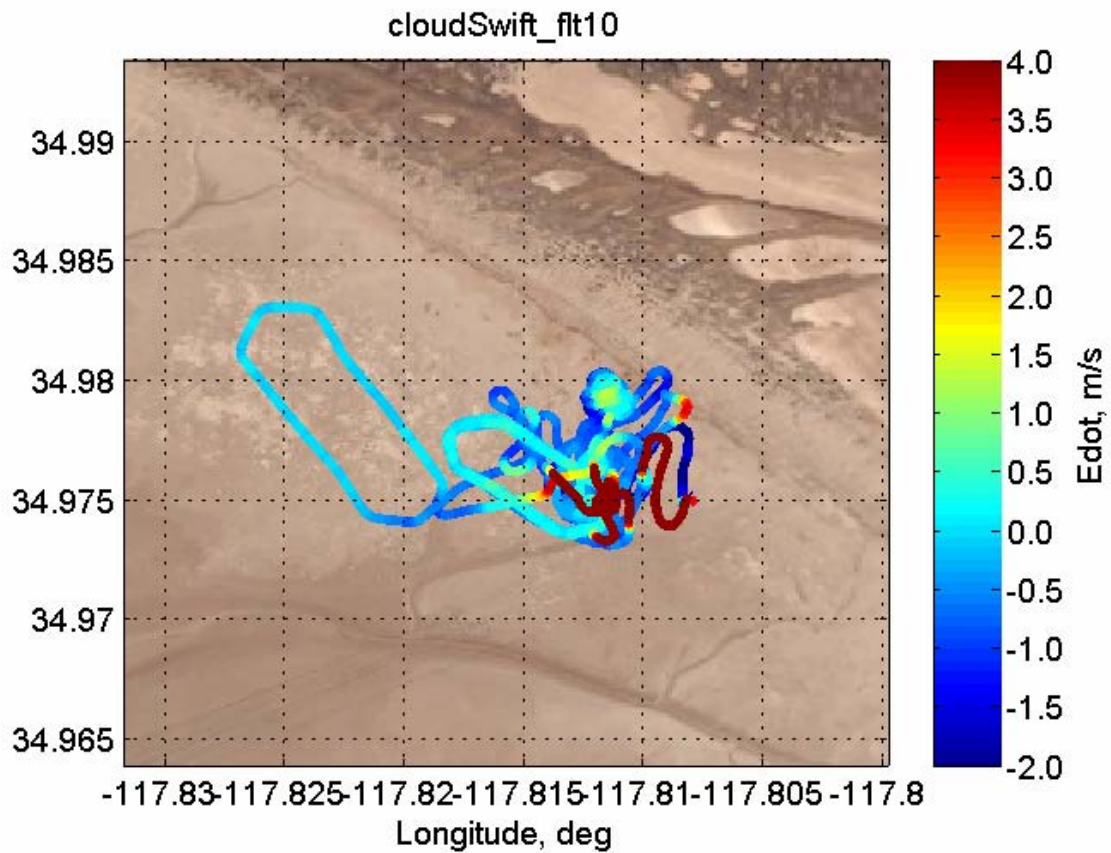


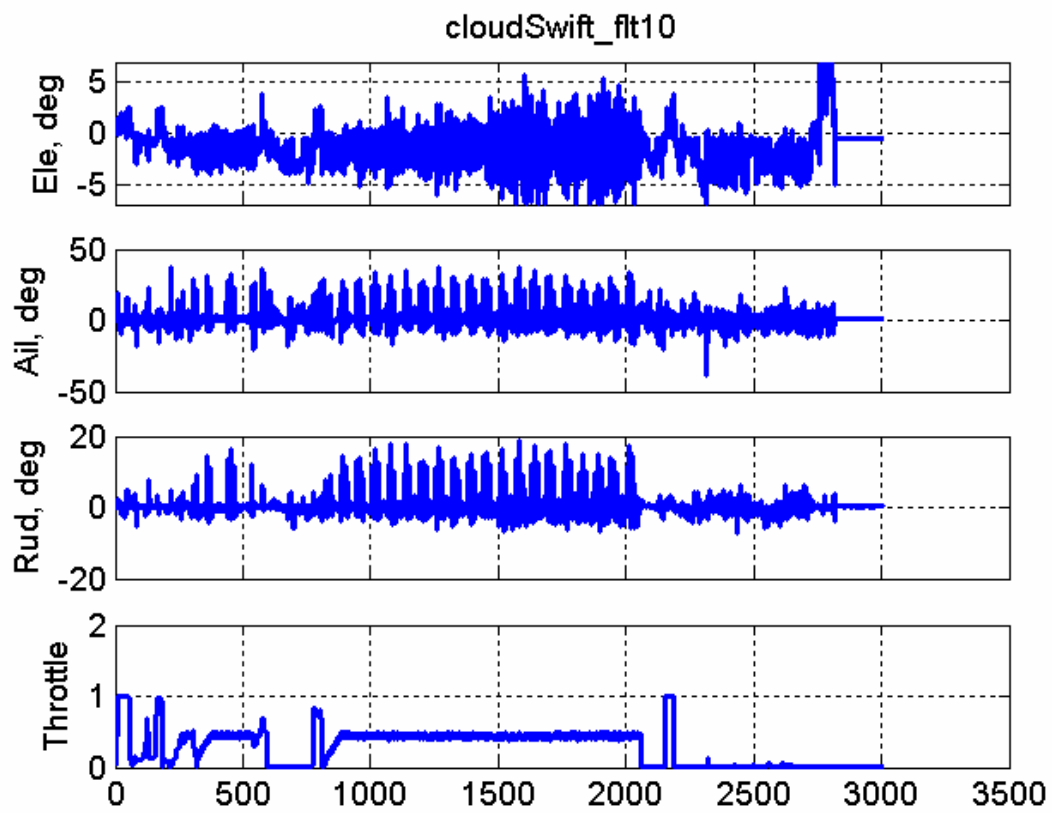


Flight 10

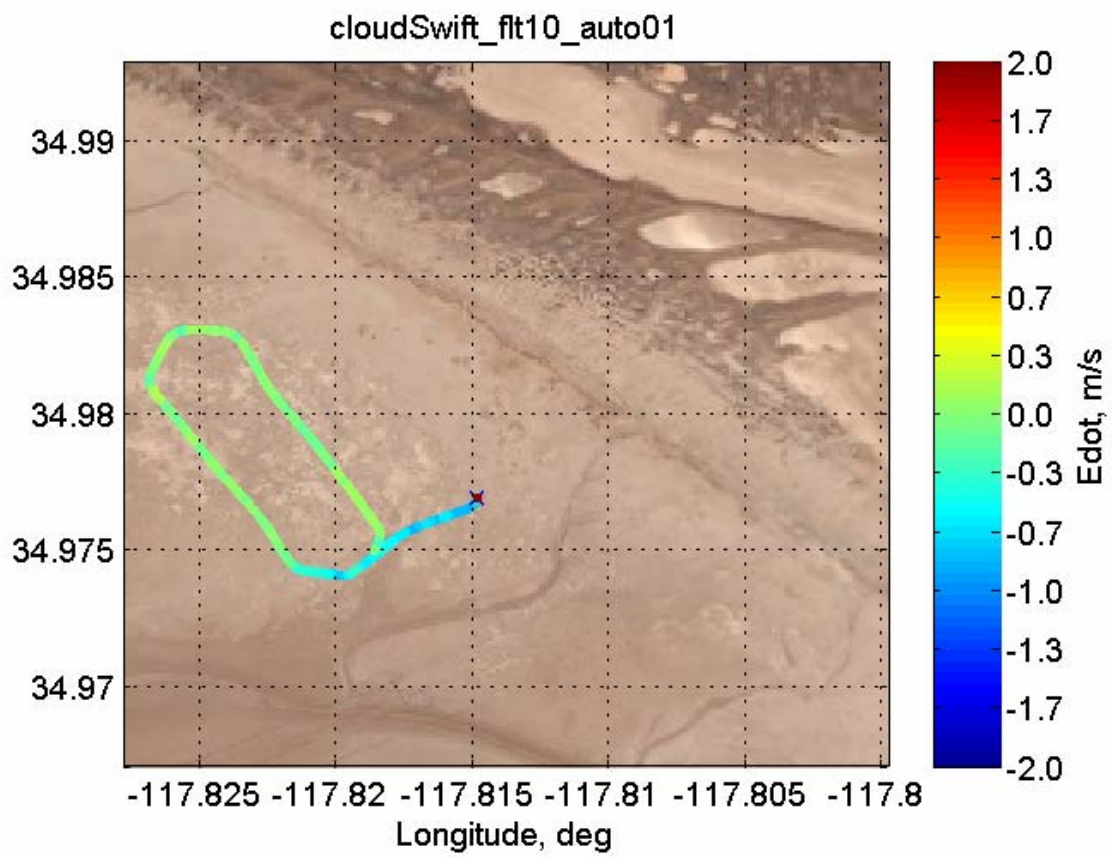
Flight 10 was used to tune the velocity gains and do some piloted soaring.

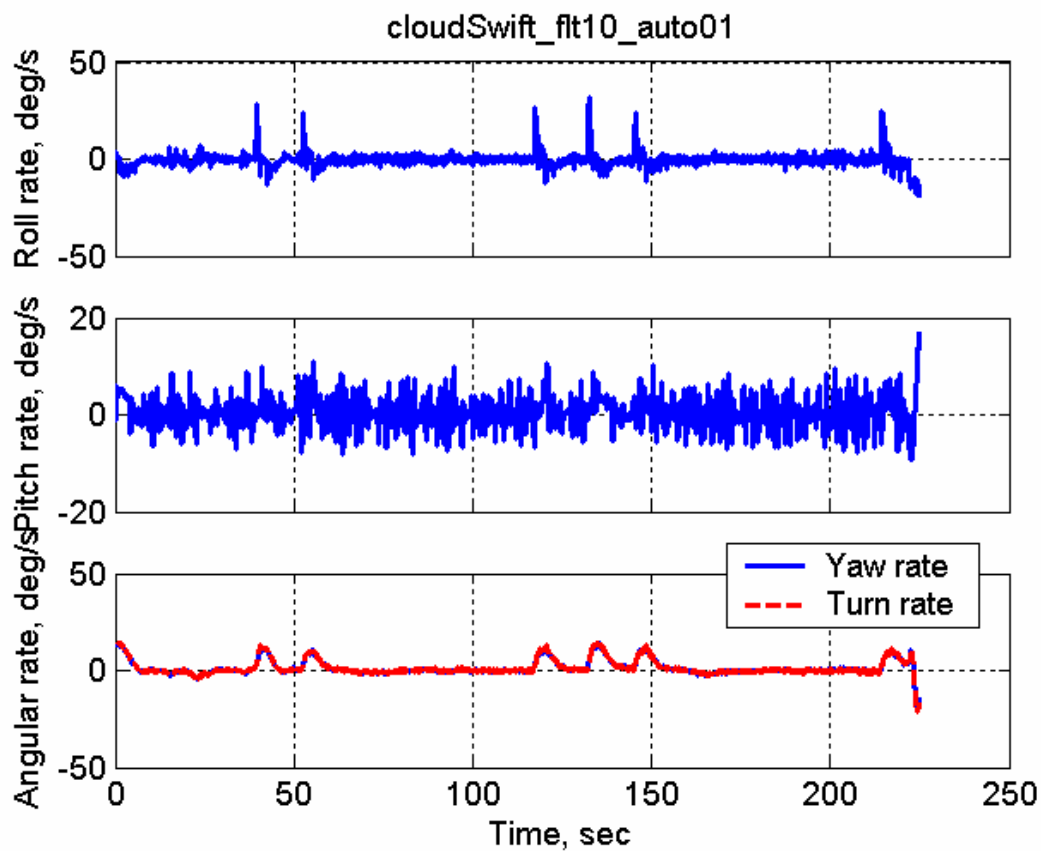
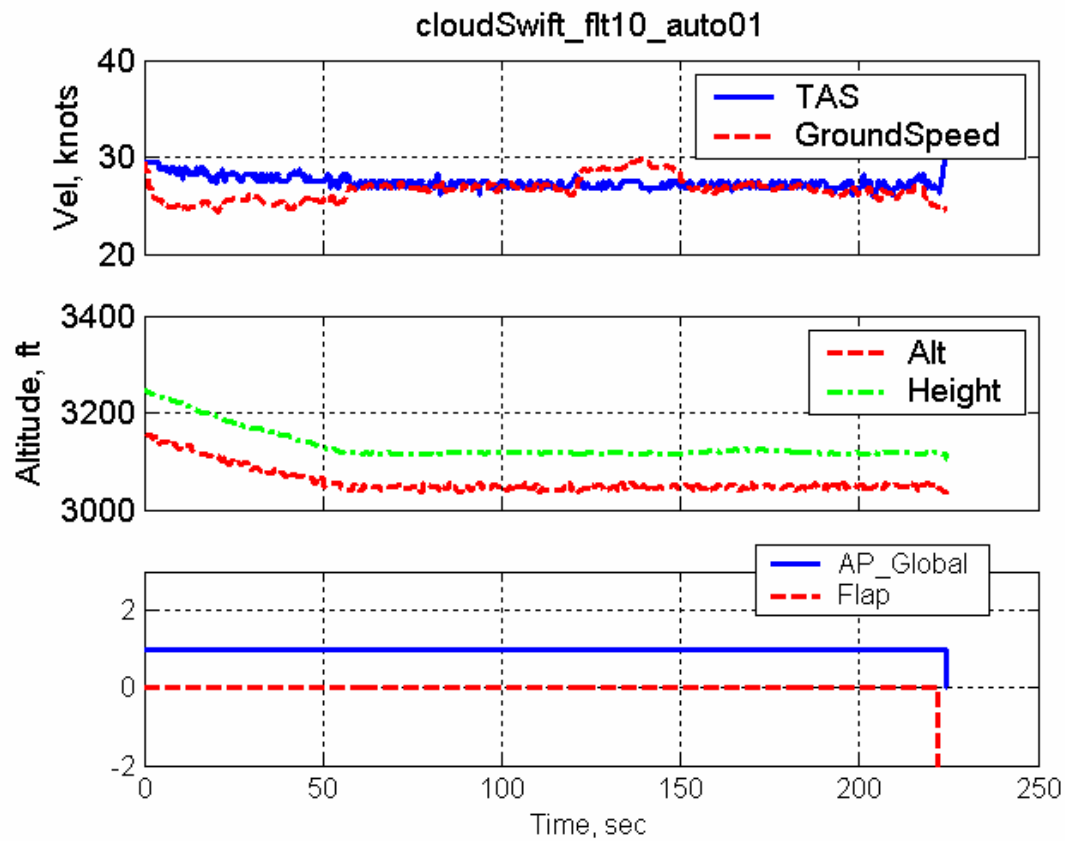


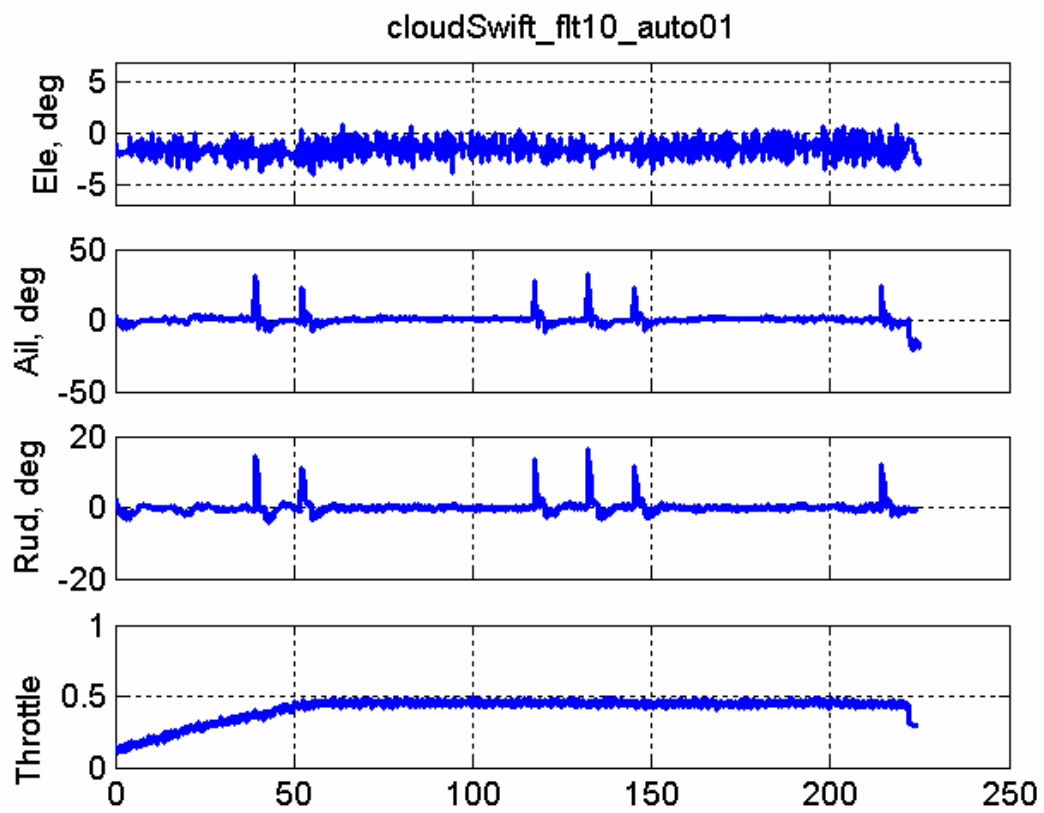




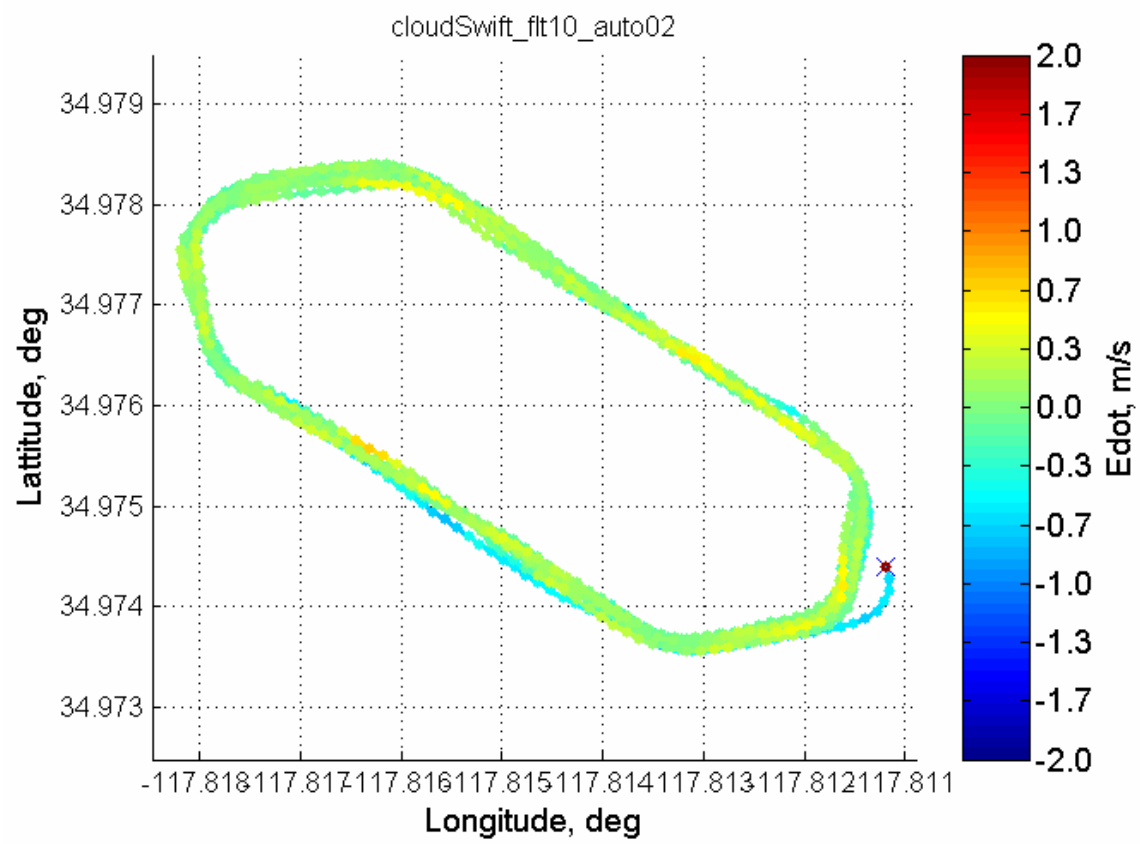
Flight 10, autonomous 1

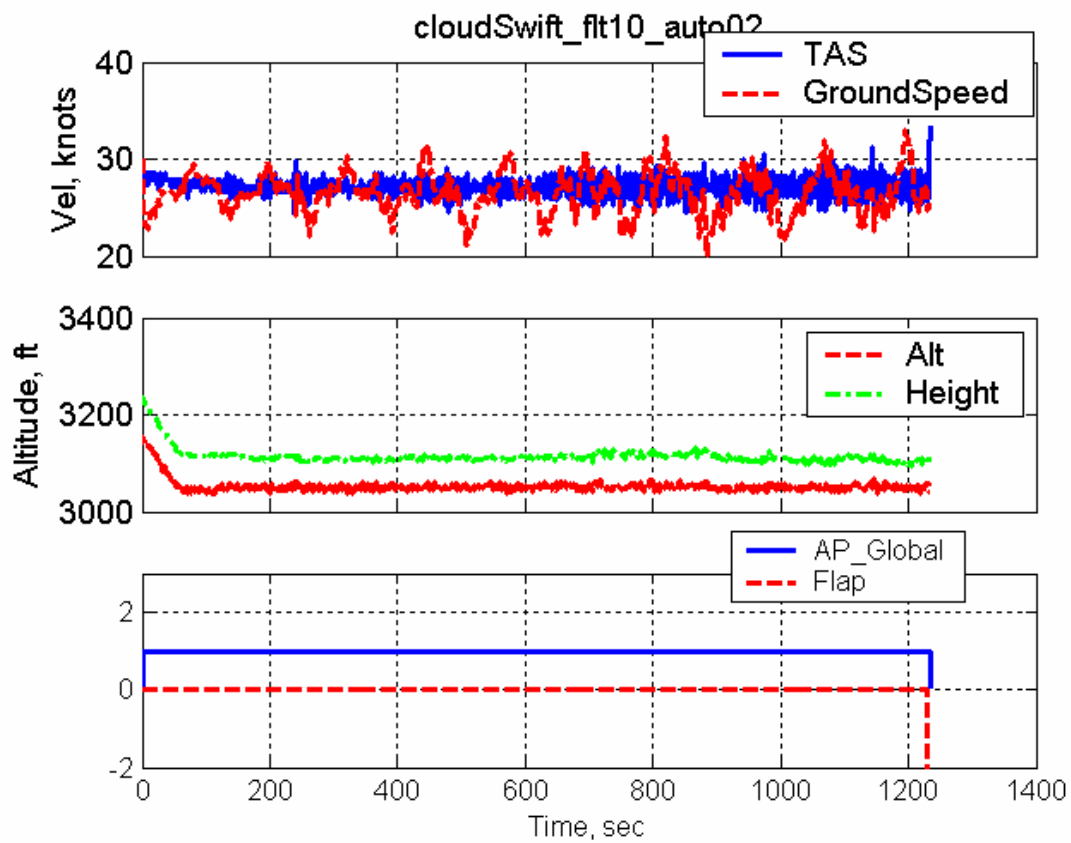
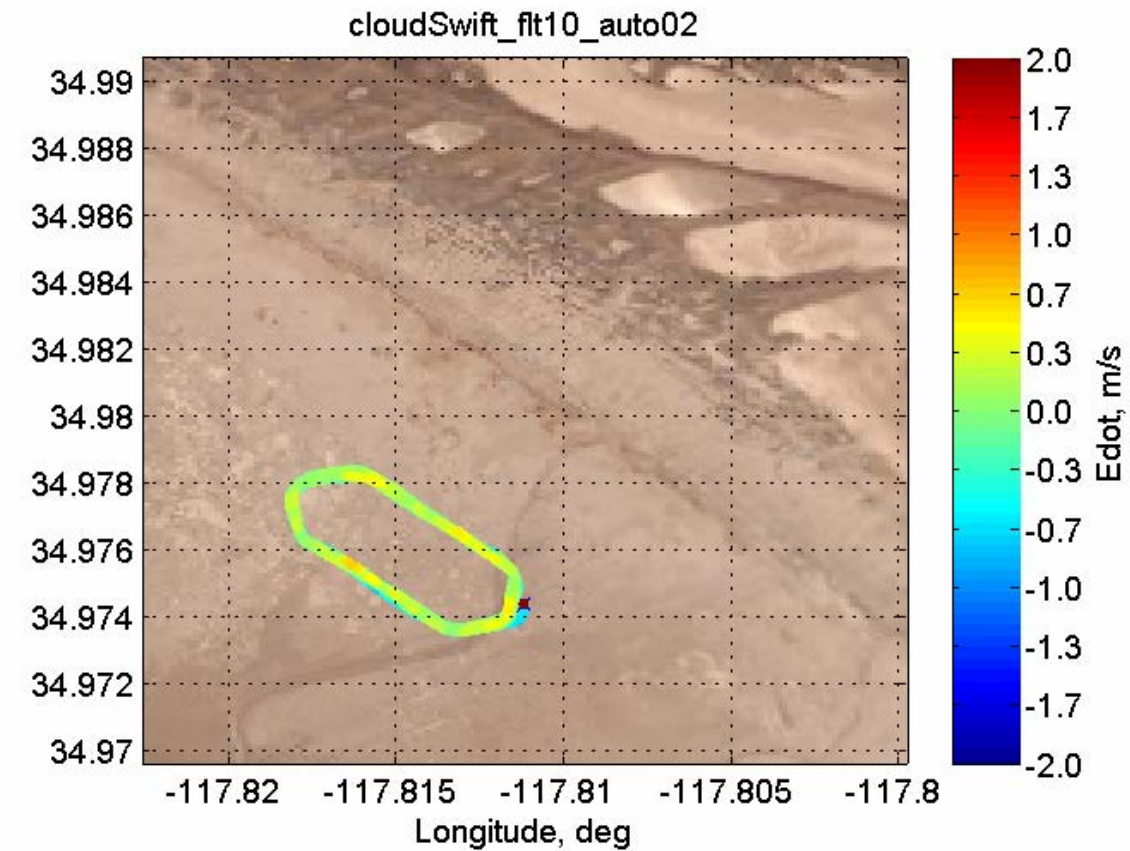


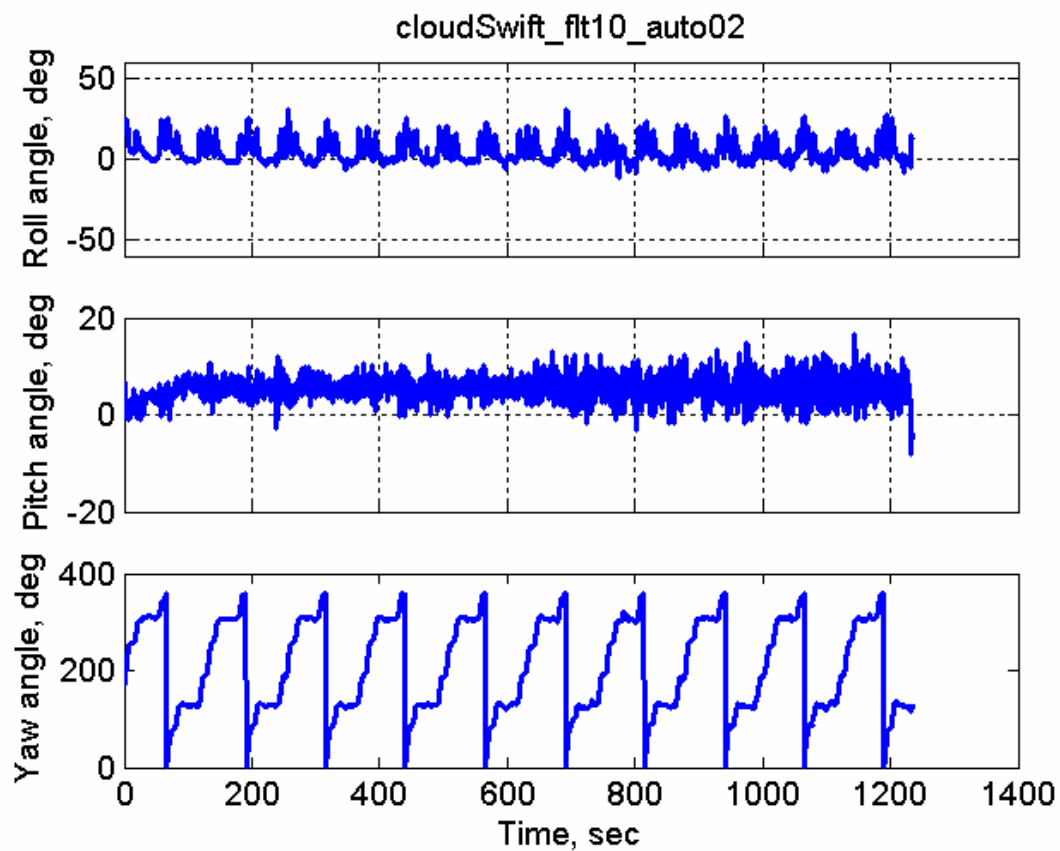
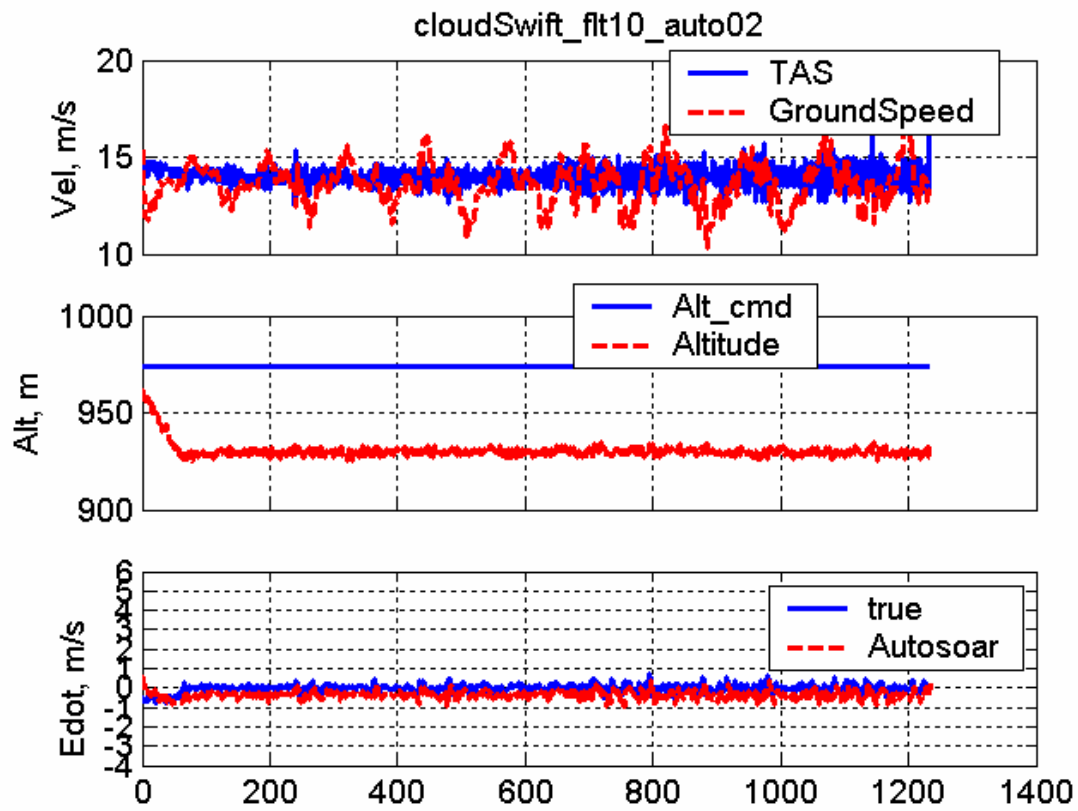


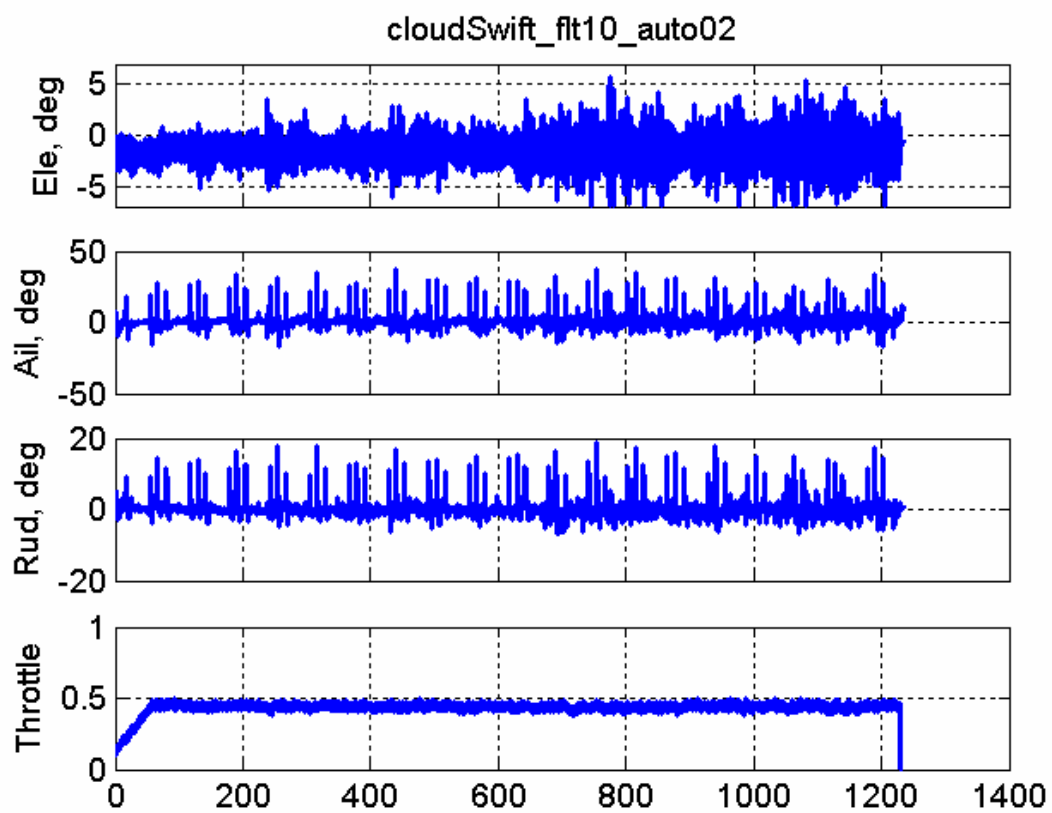


Flight 10, autonomous 2

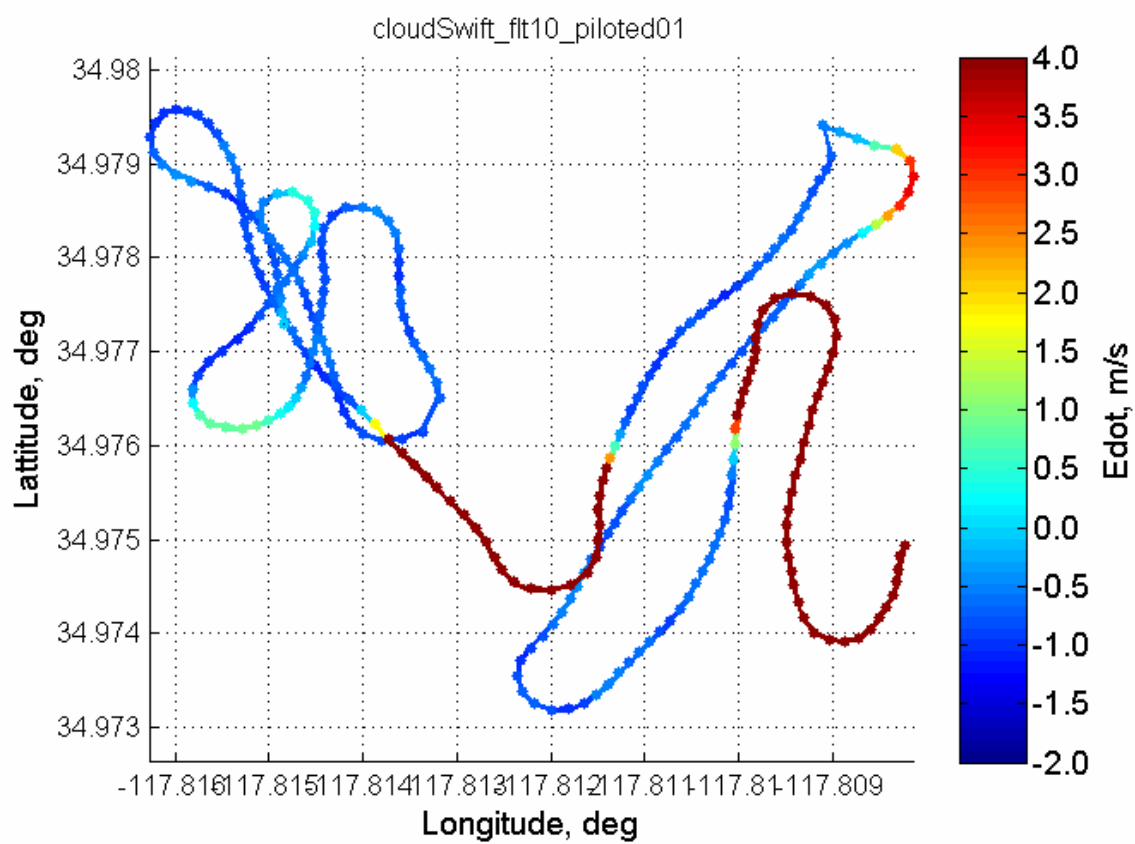


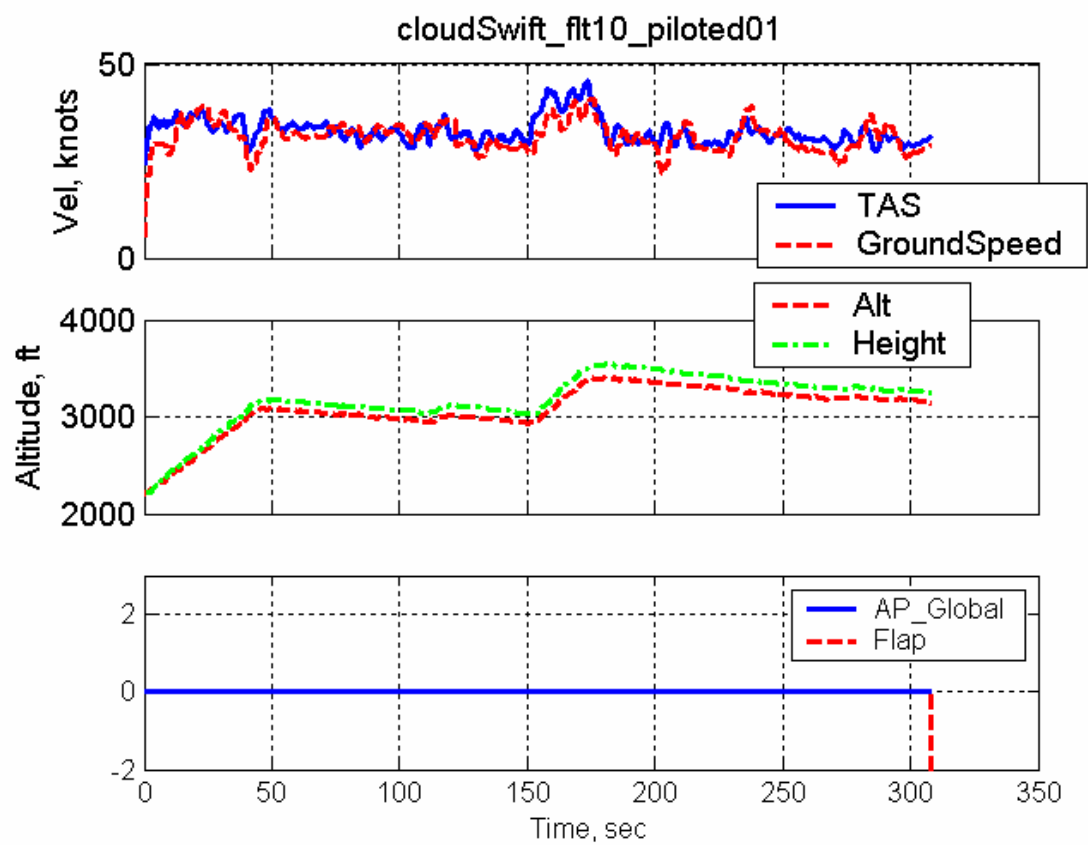
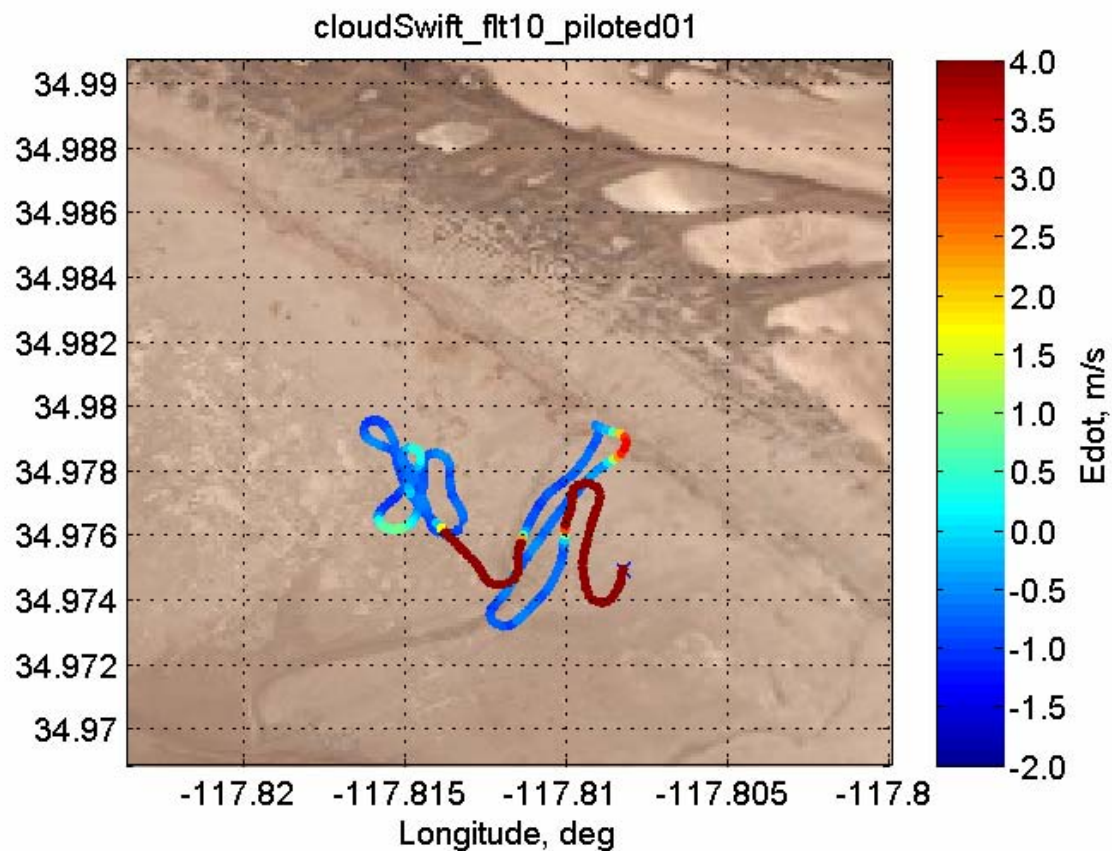


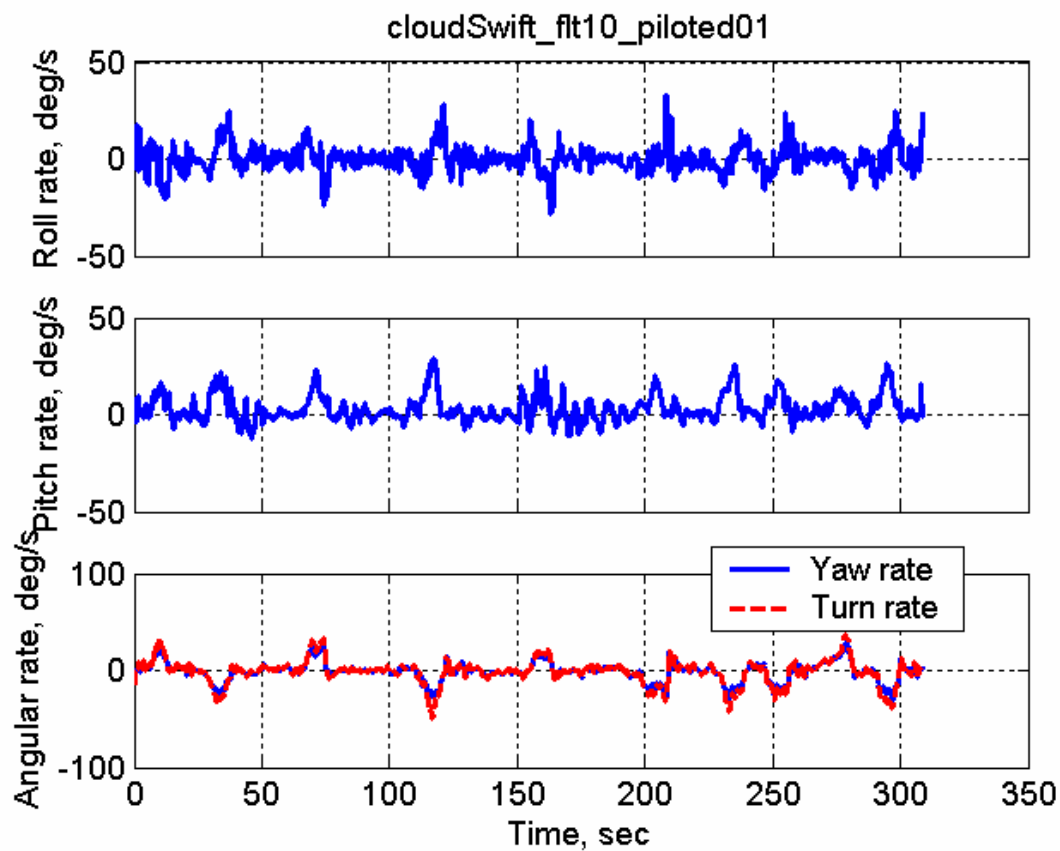
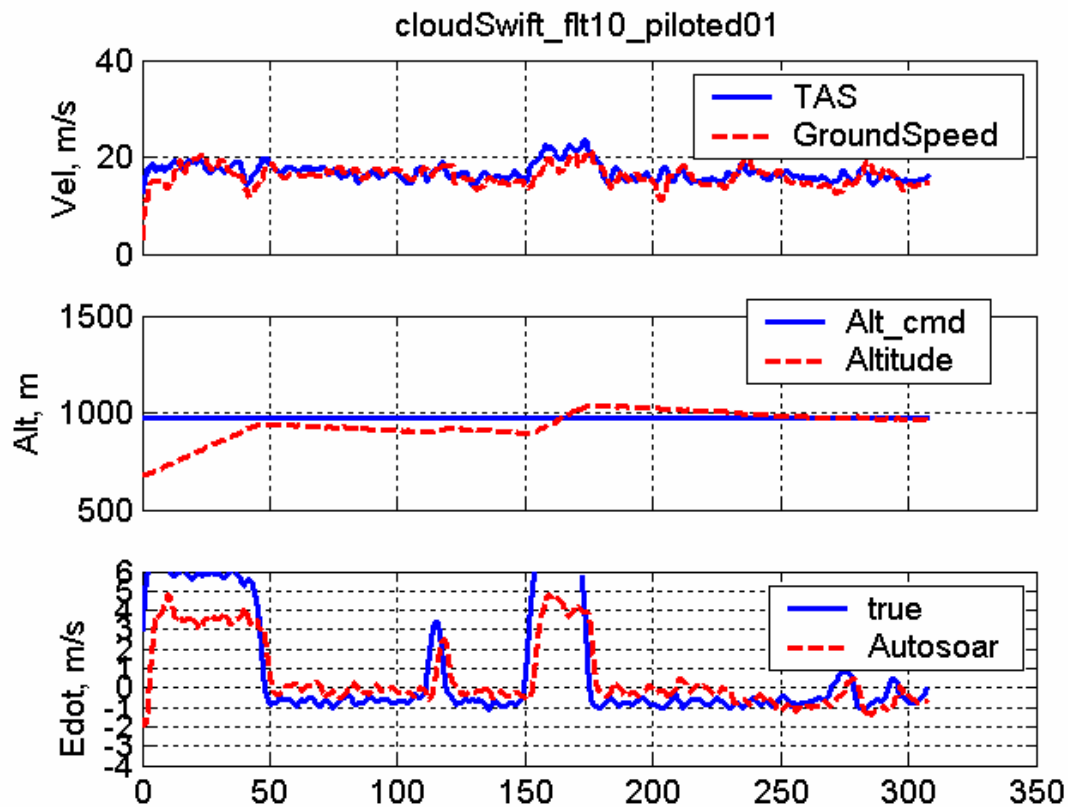


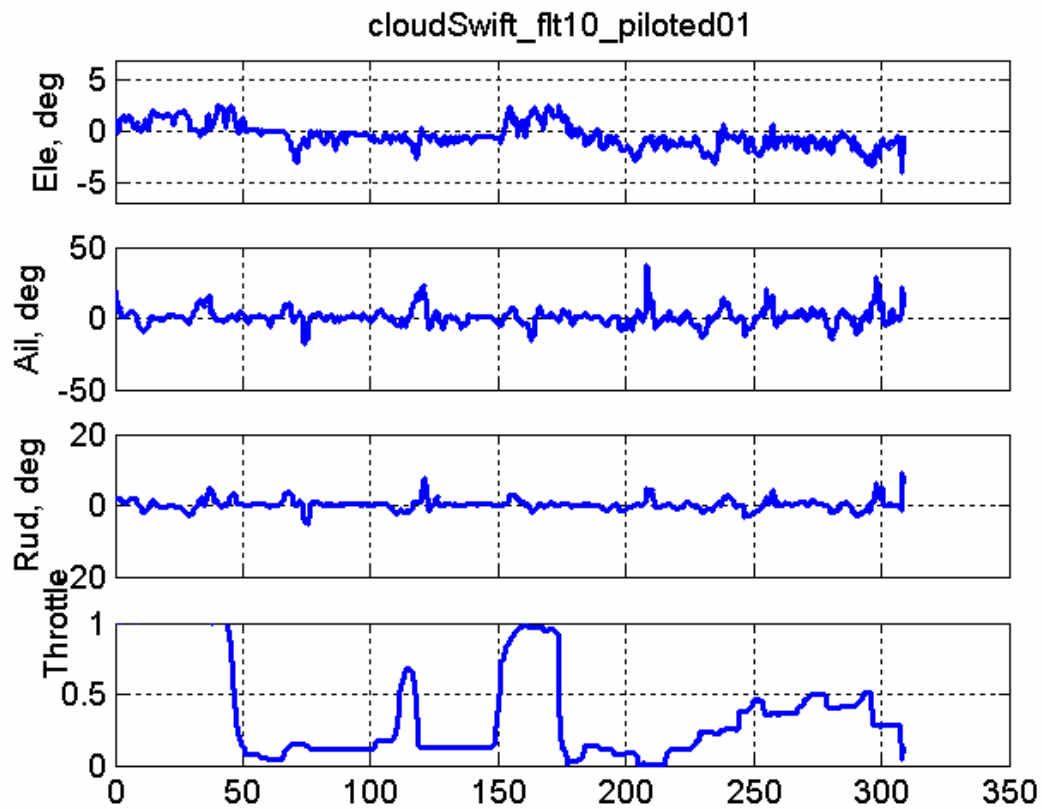
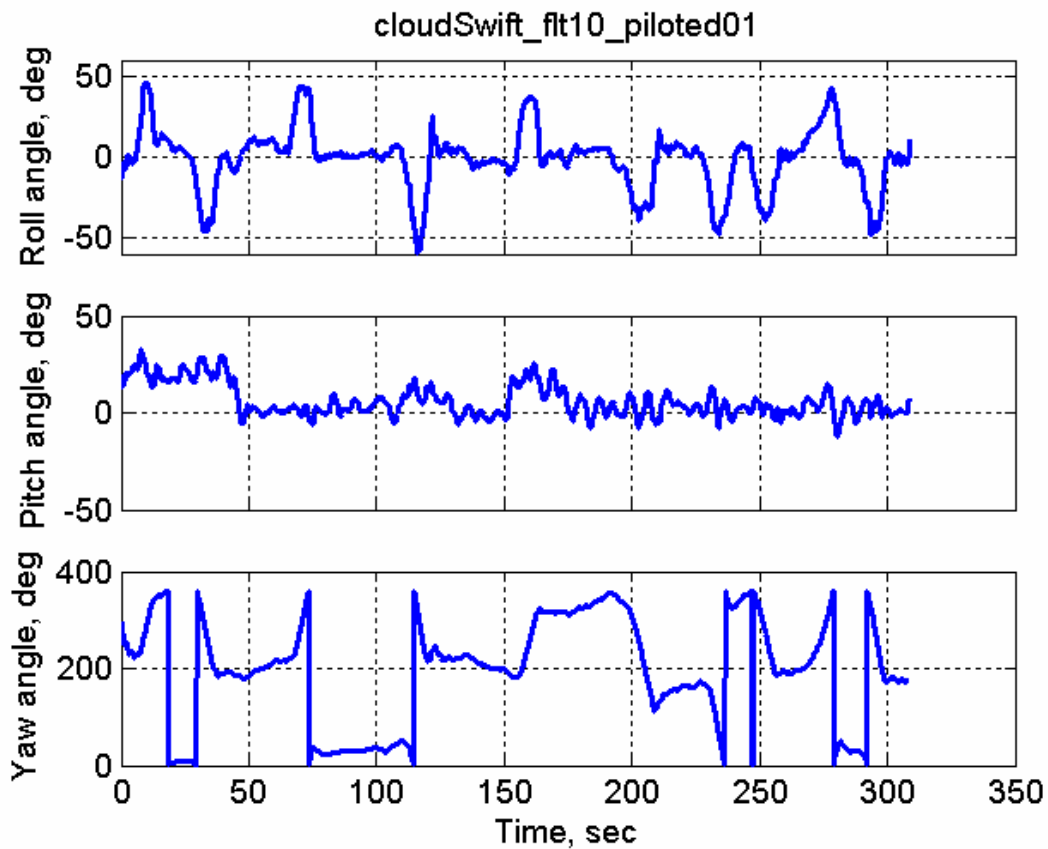


Flight 10, piloted 1

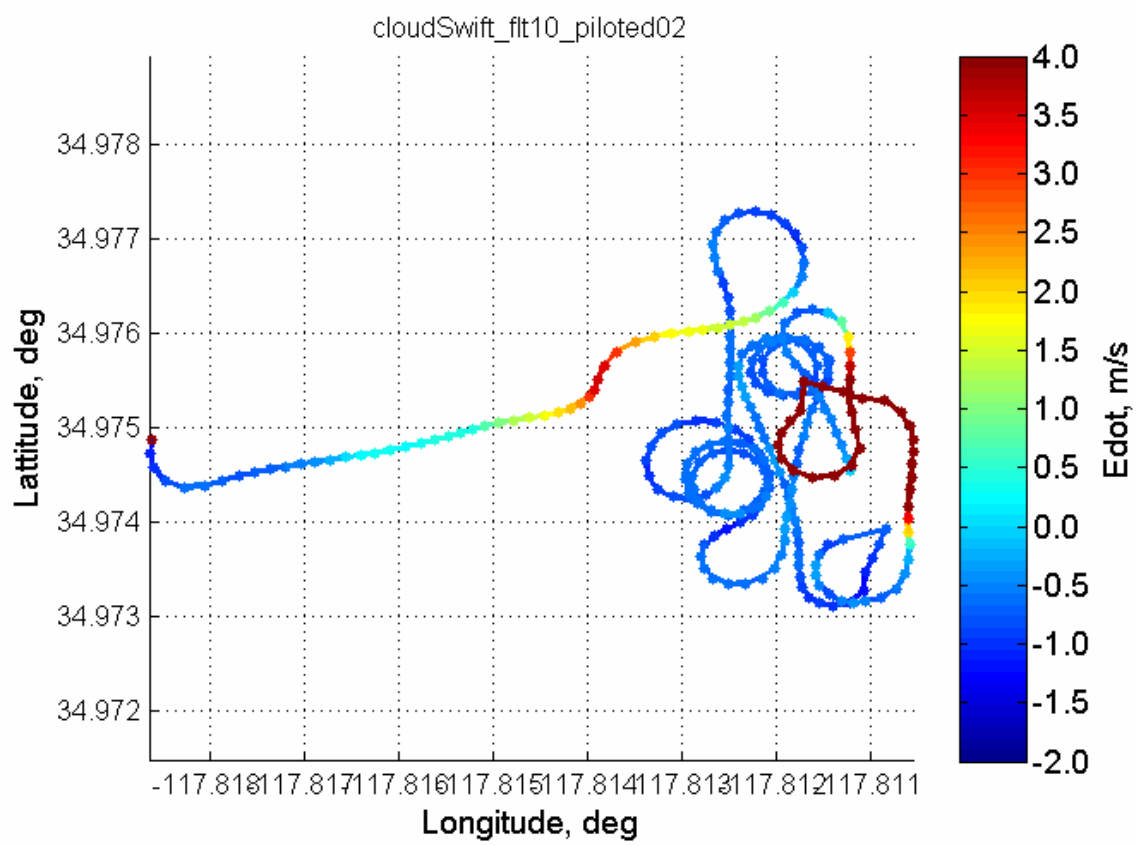


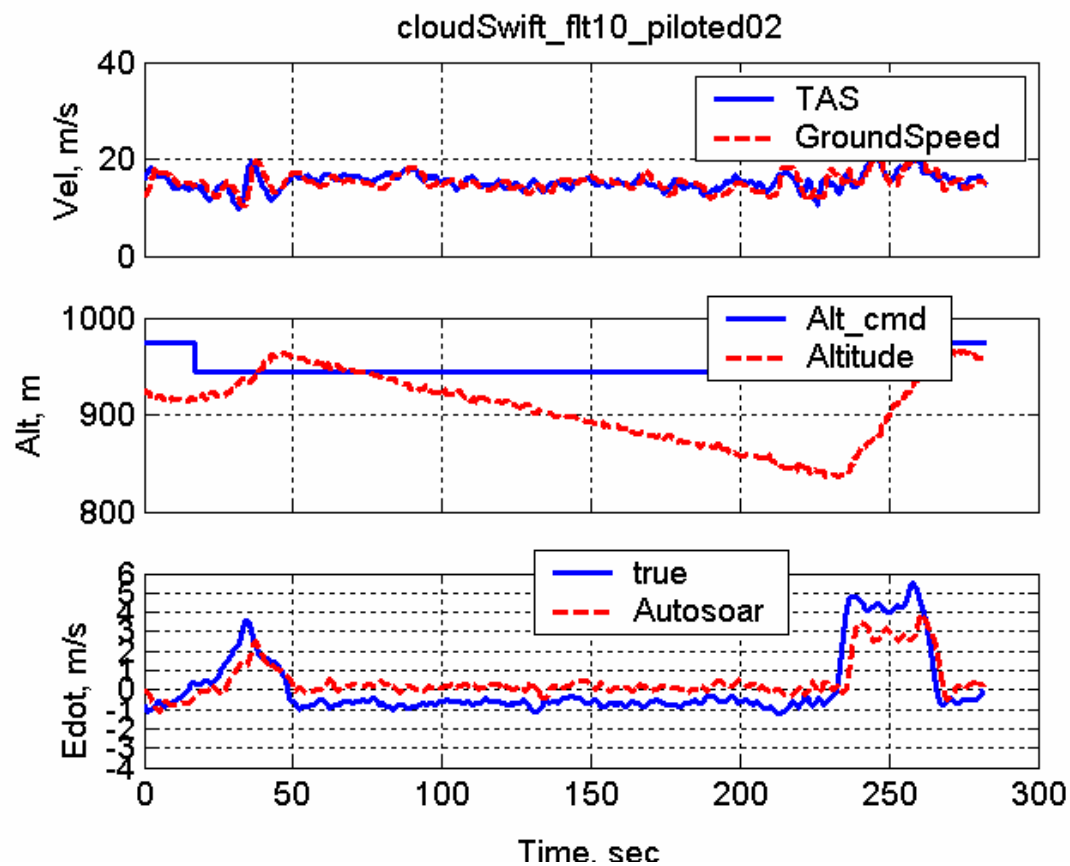
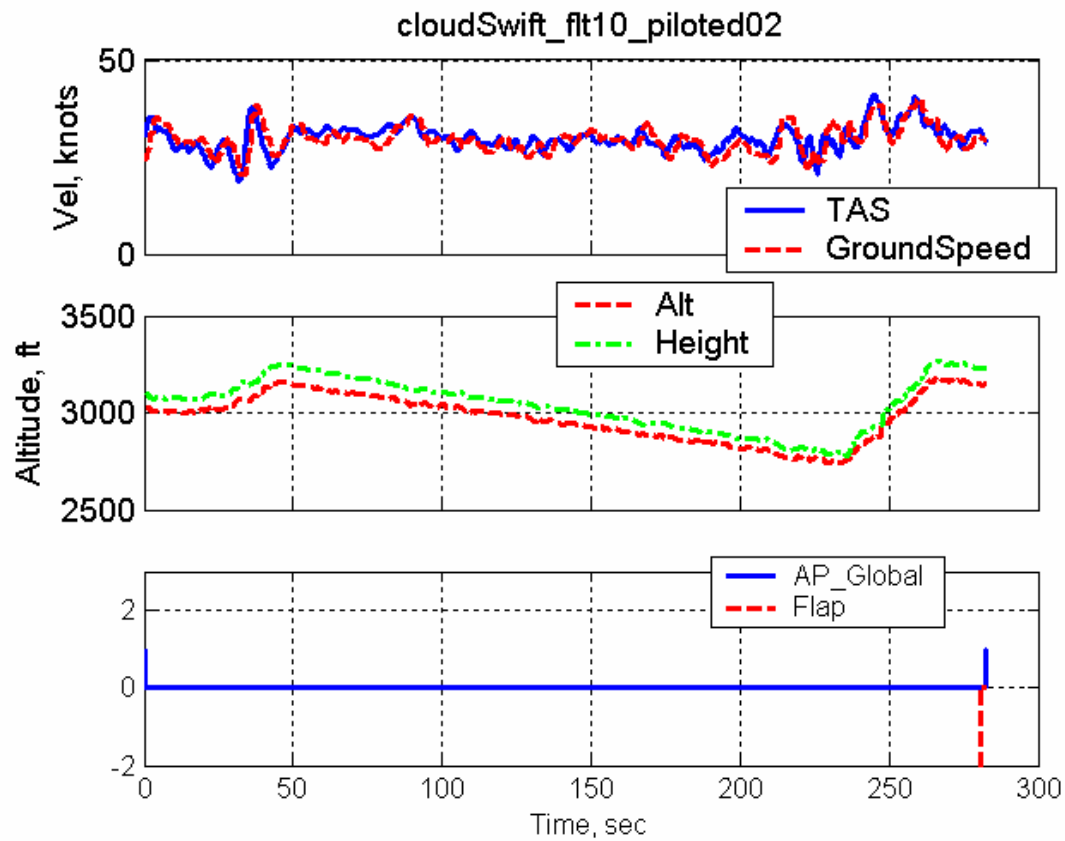


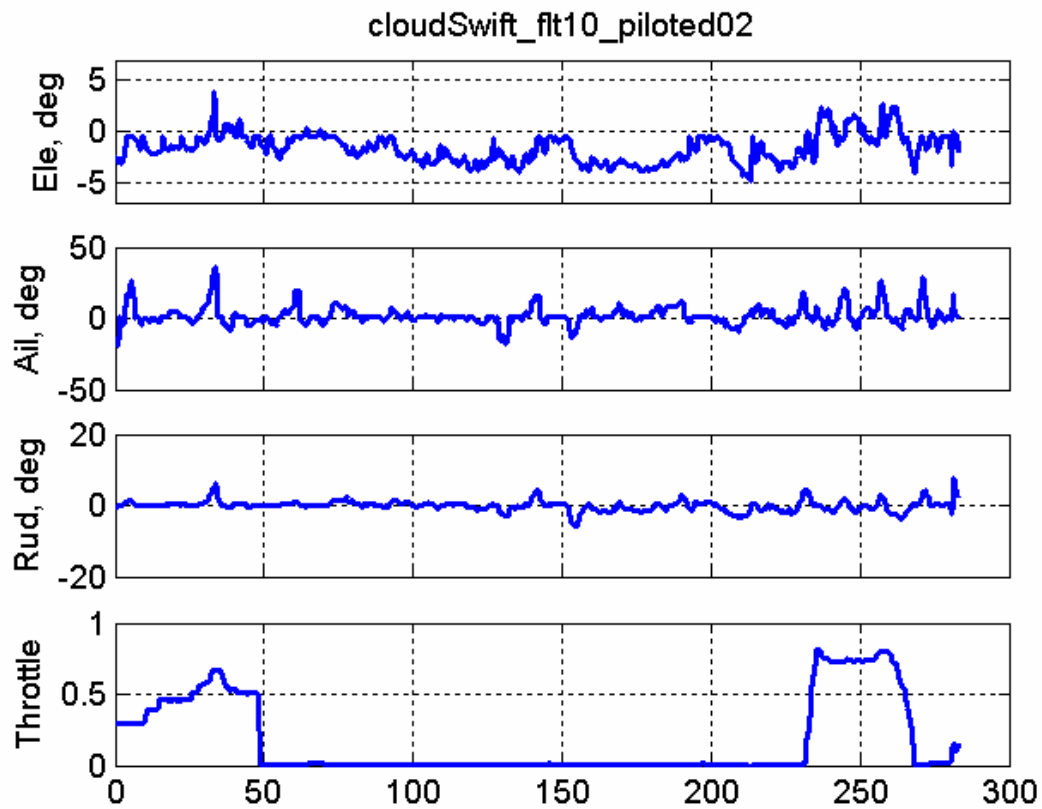
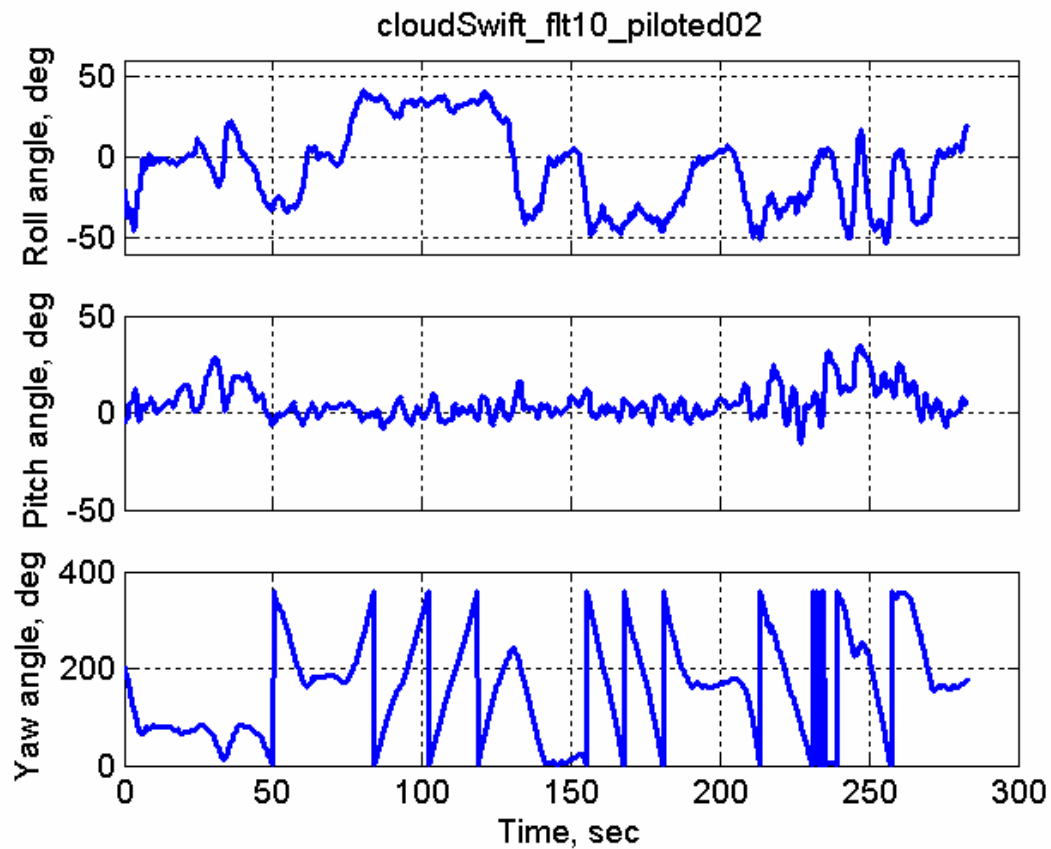




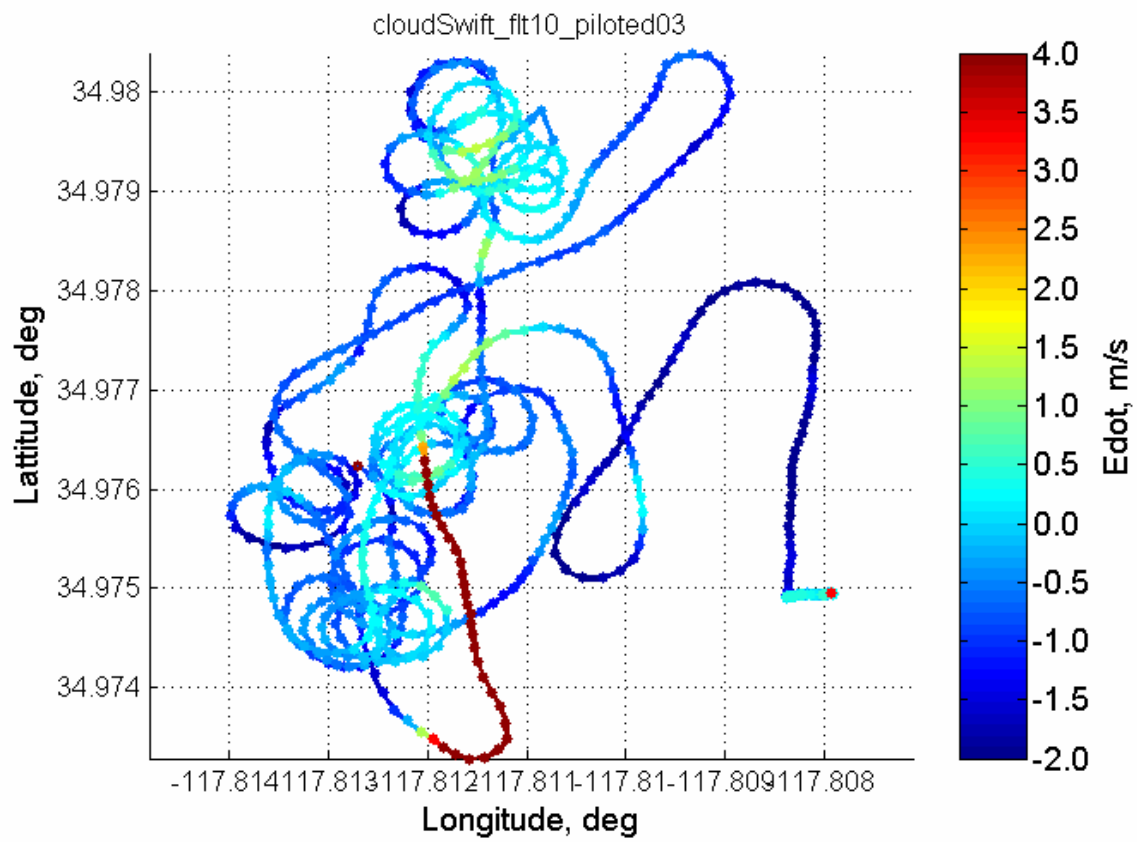
Flight 10, piloted 2

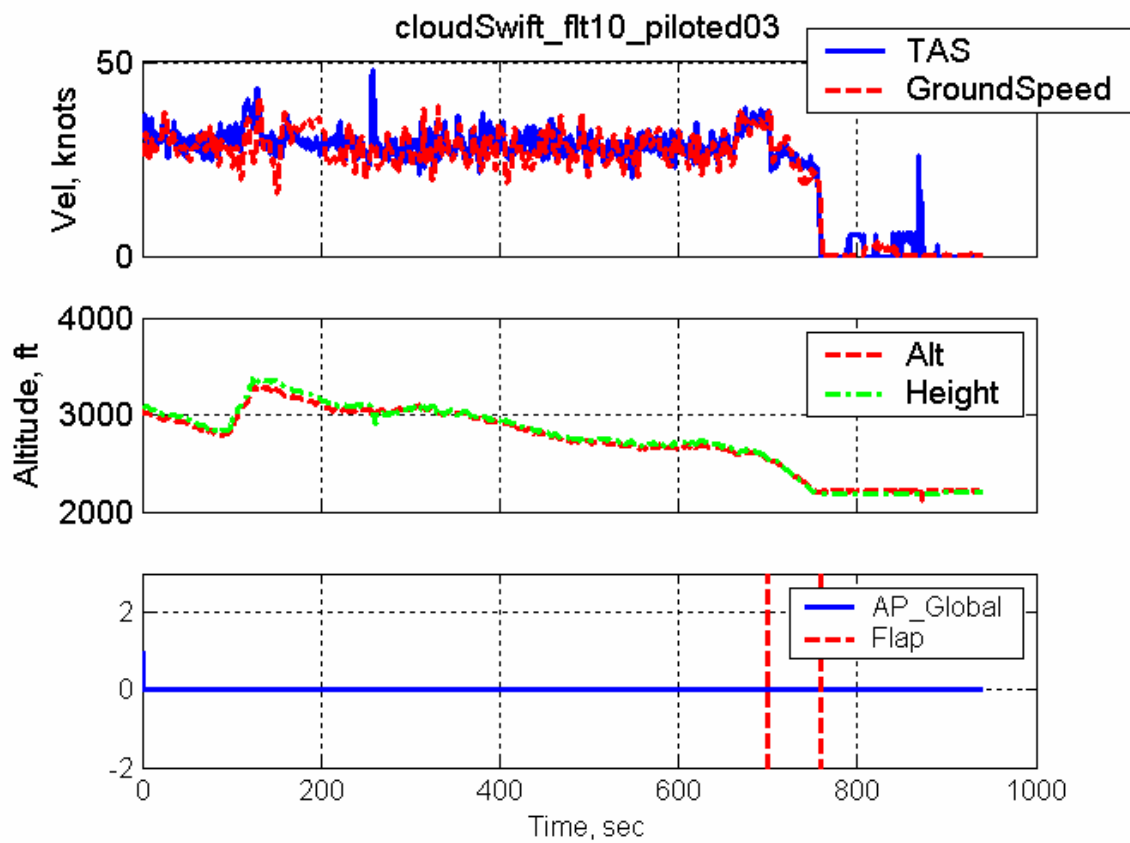
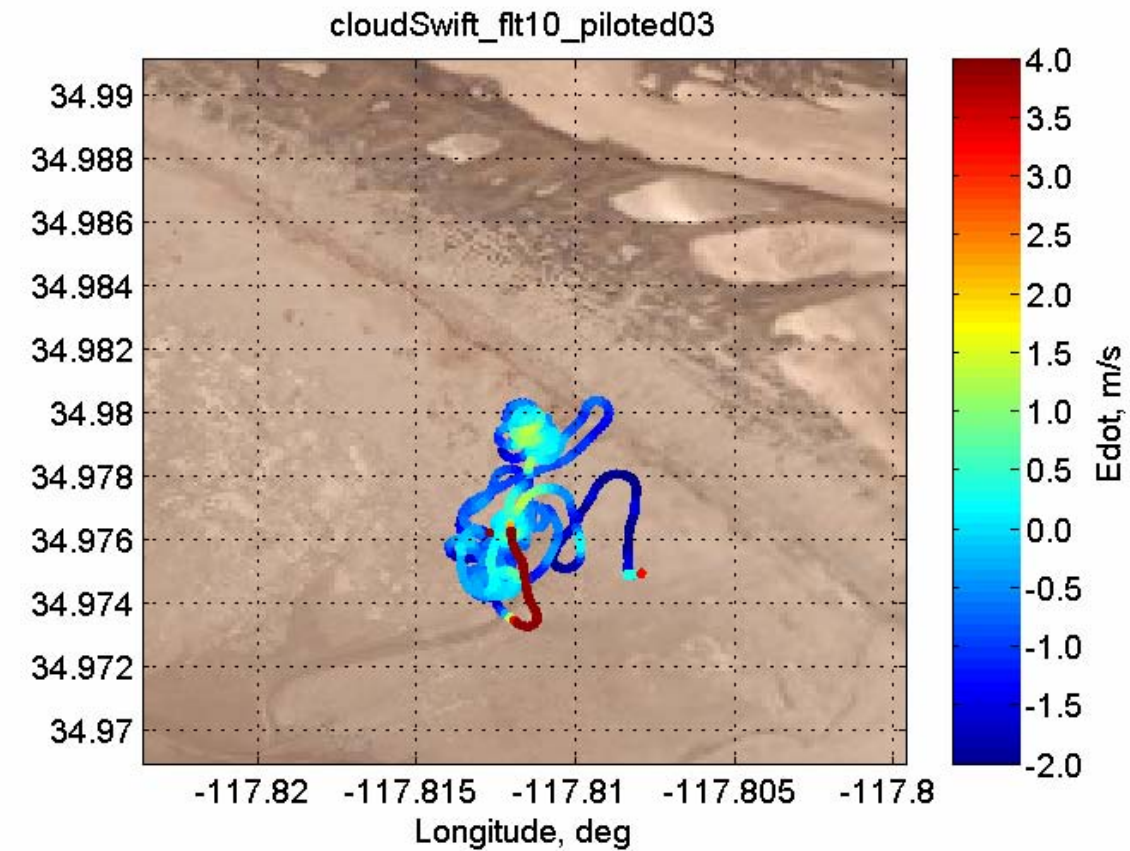


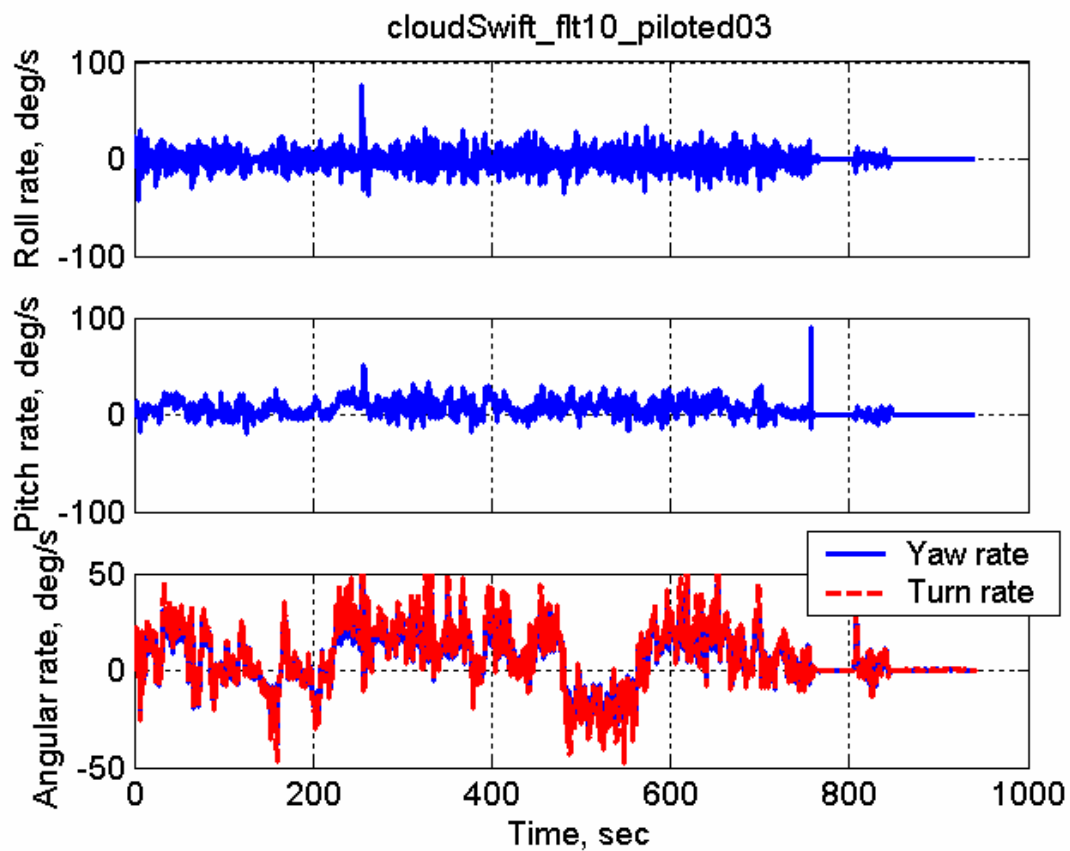
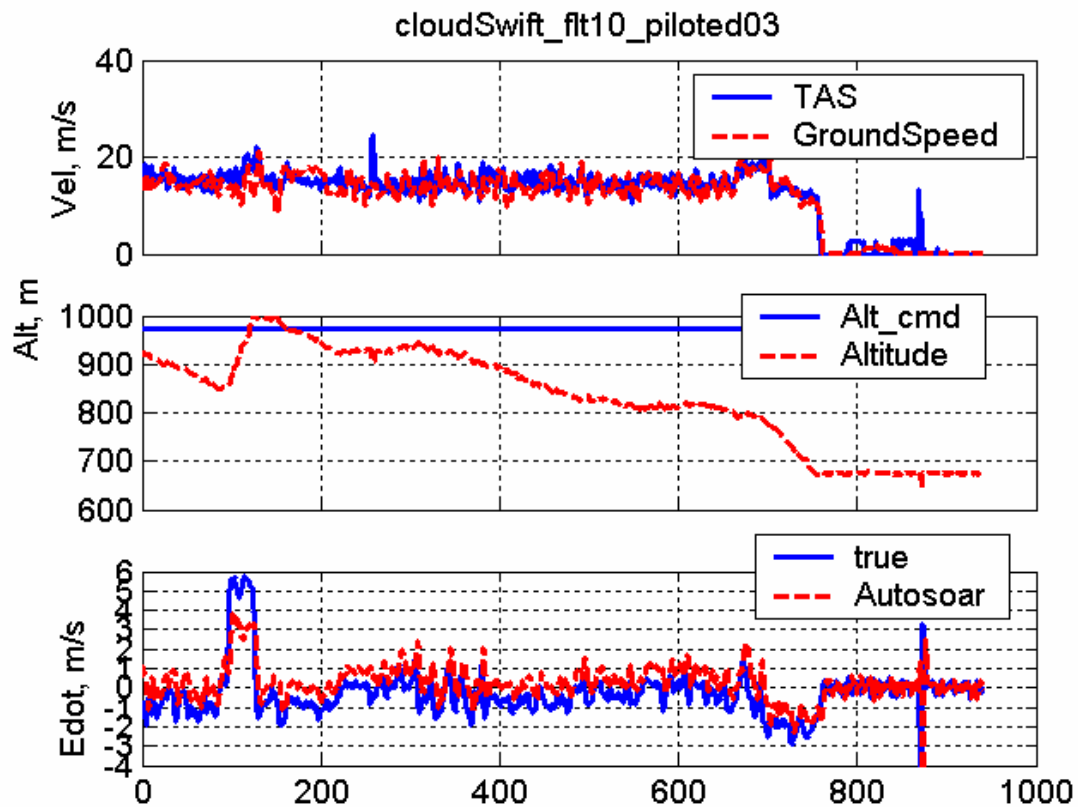


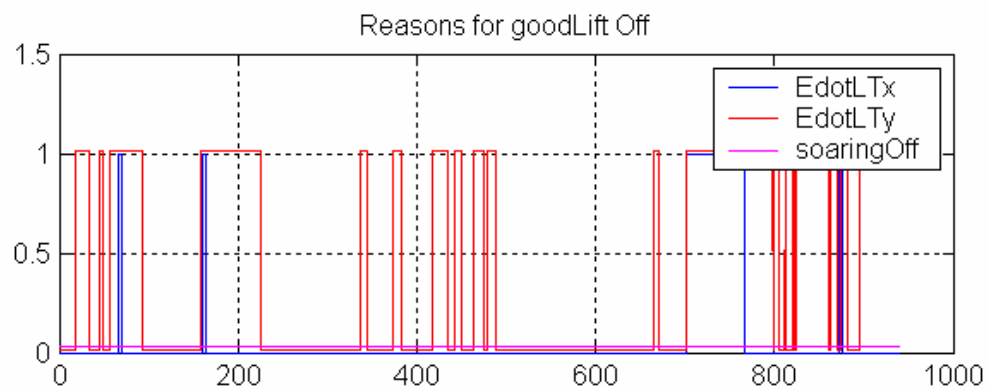
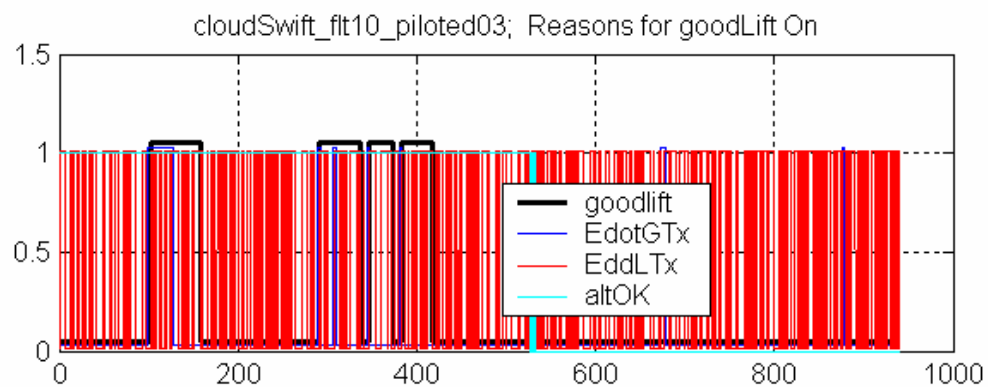
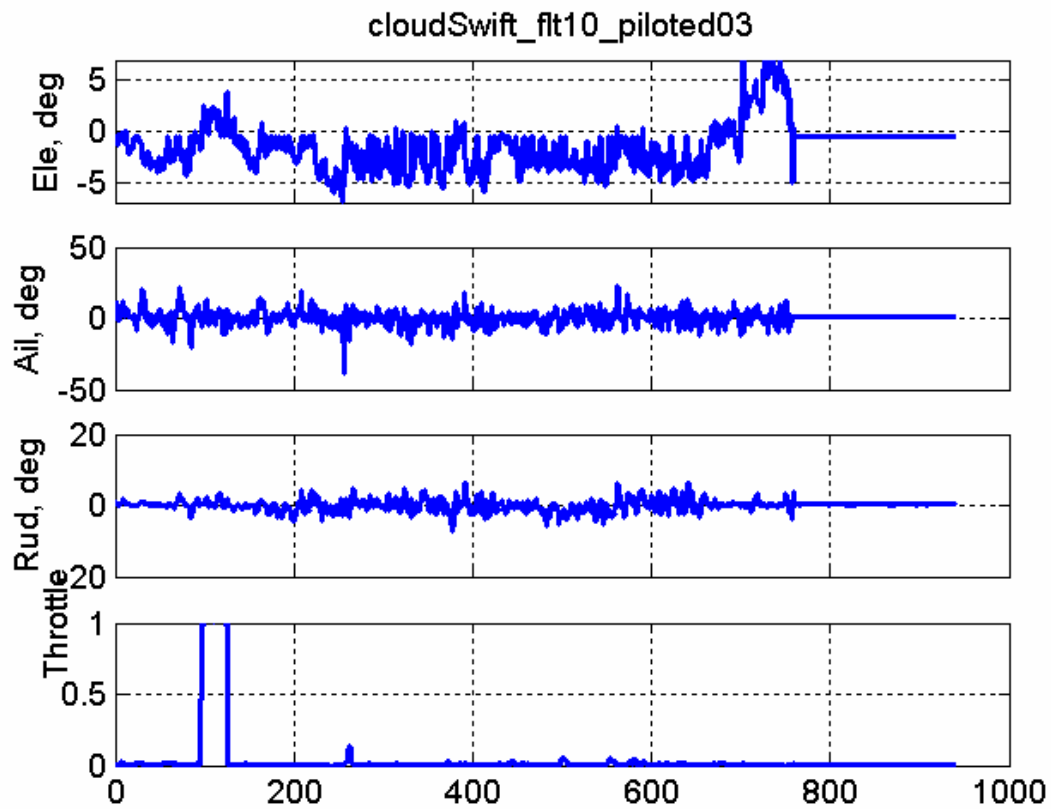


Flight 10, piloted 3



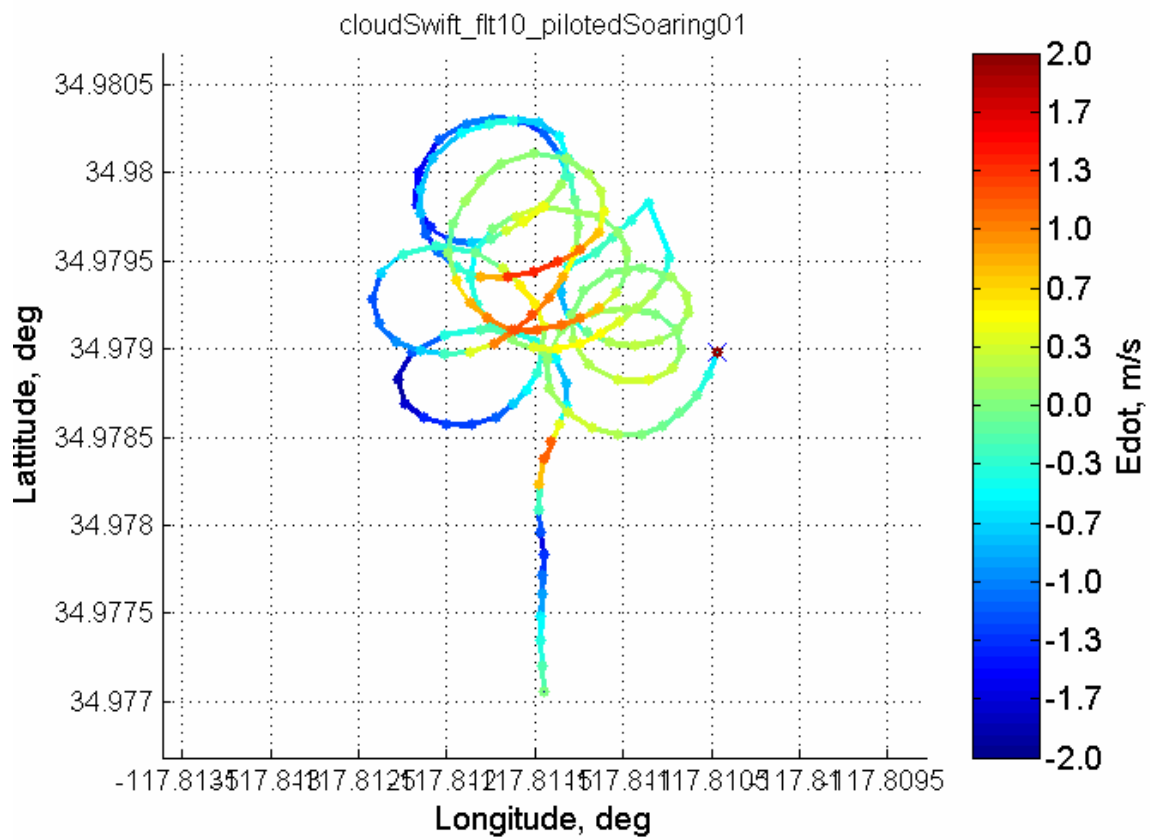


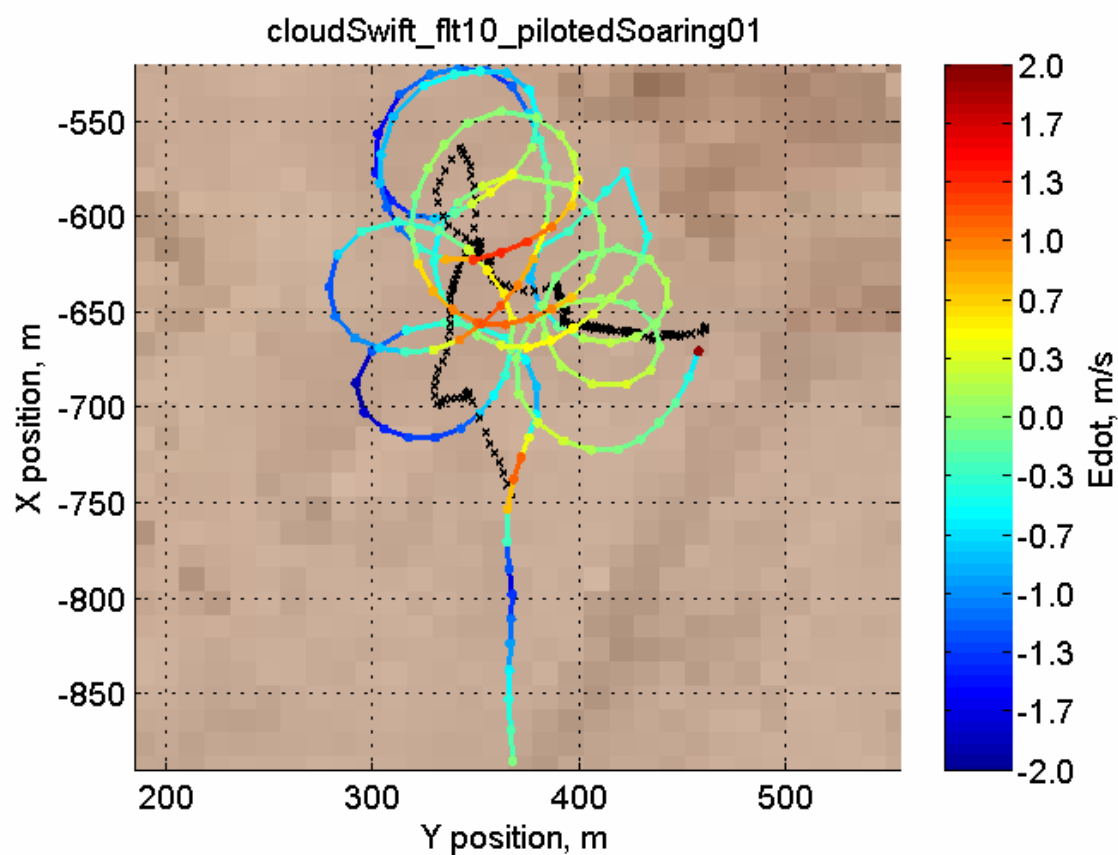
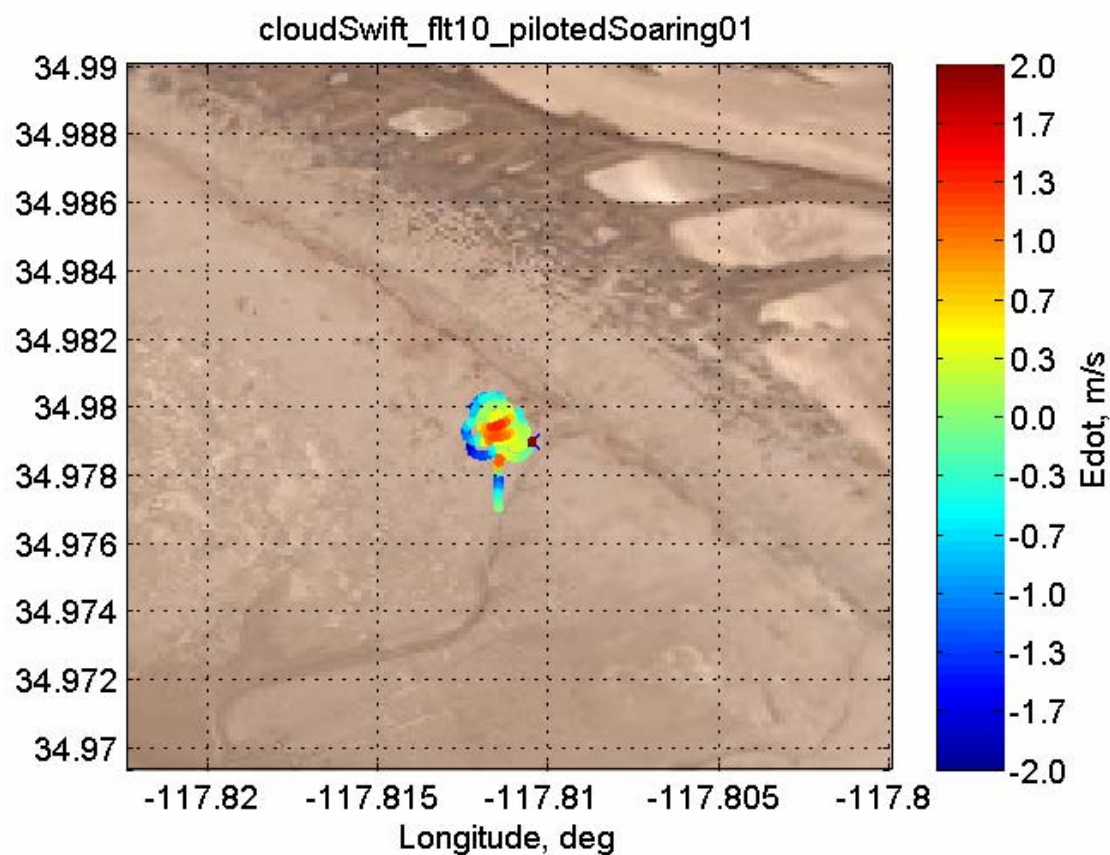


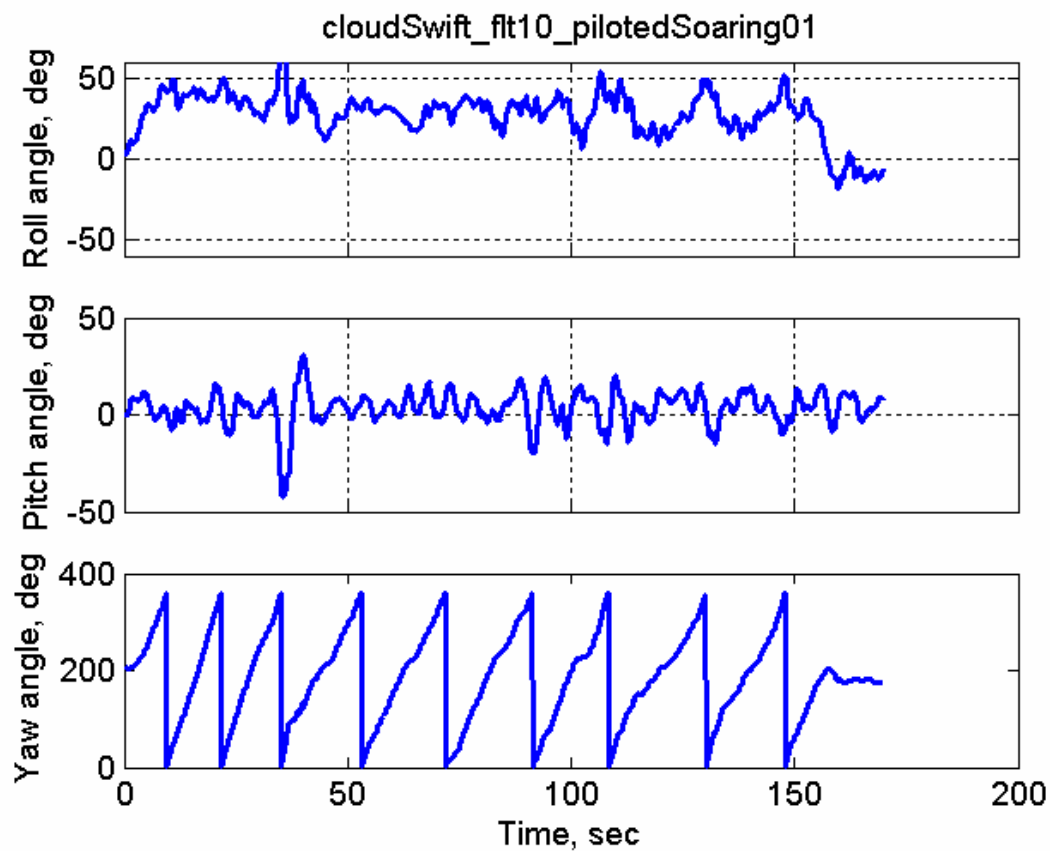
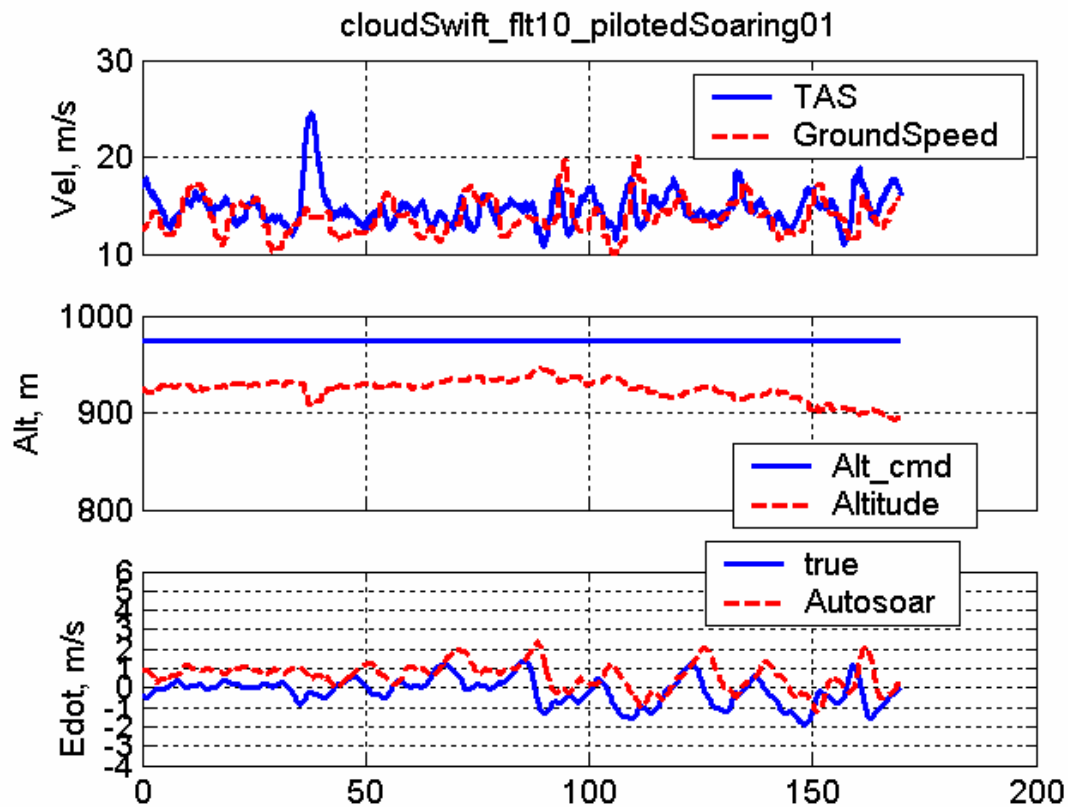


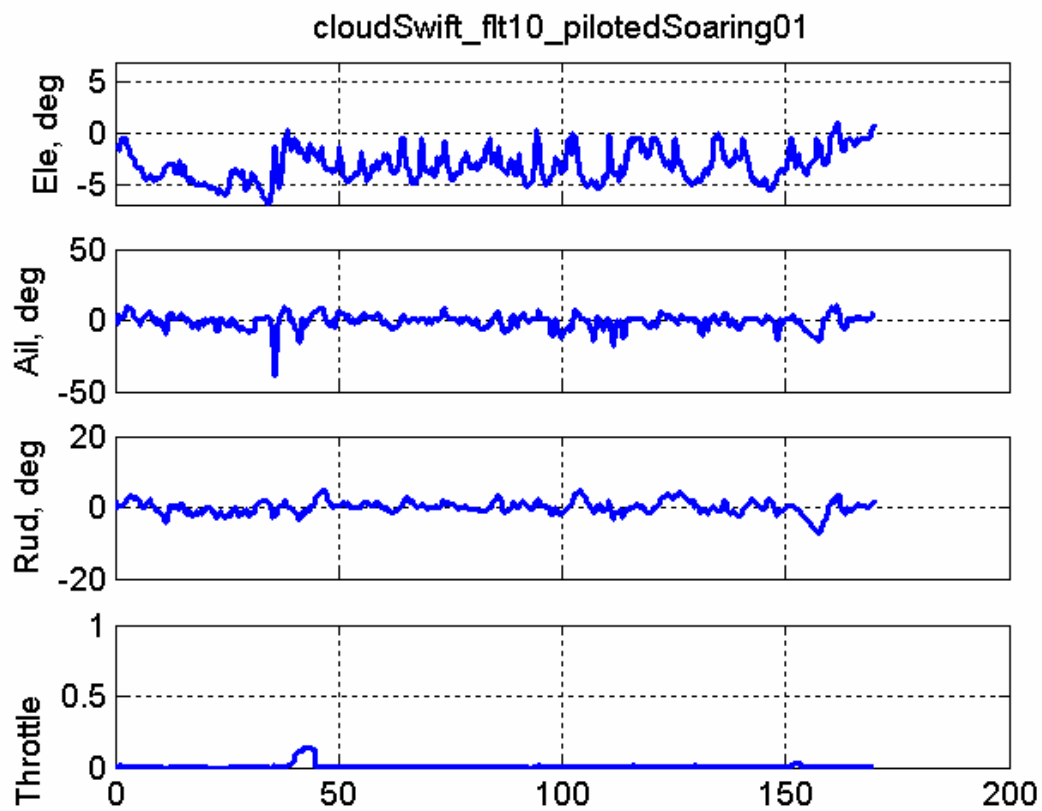
Flight 10, piloted soaring 1

Poor centering in moderate lift. Aircraft path goes around edge of thermal.



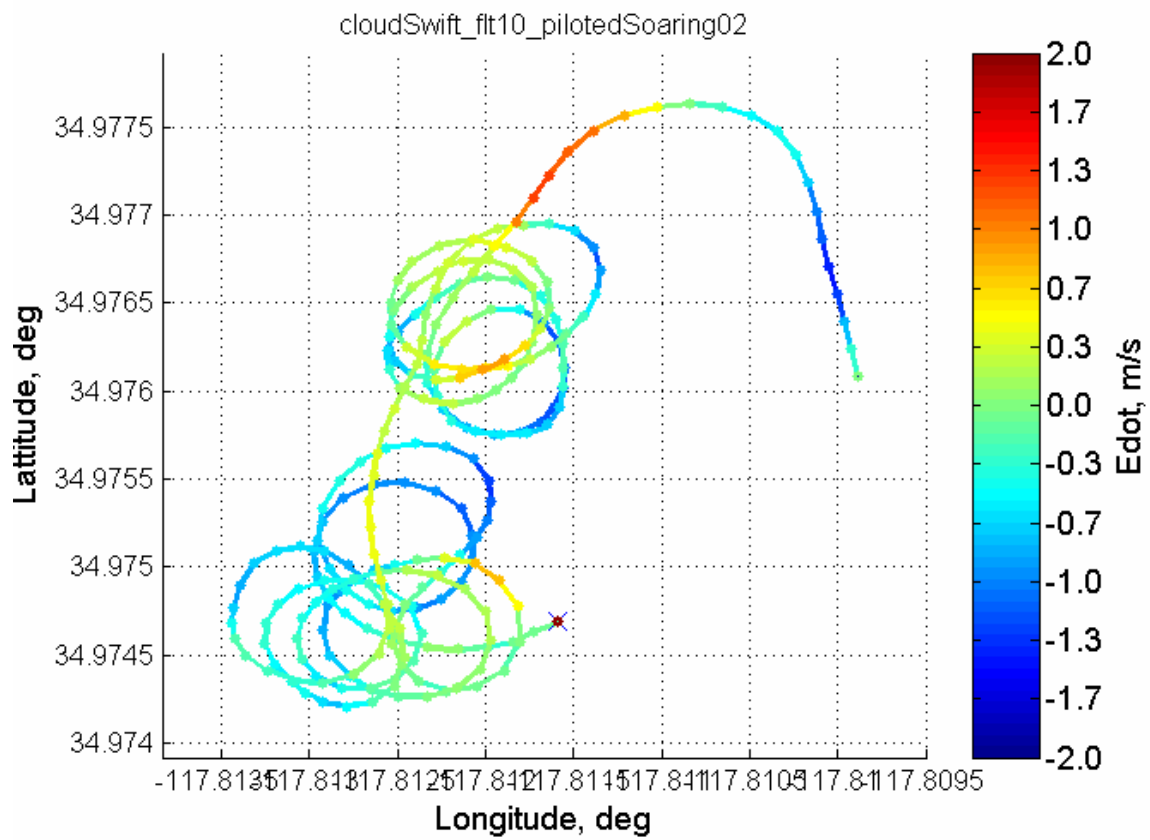


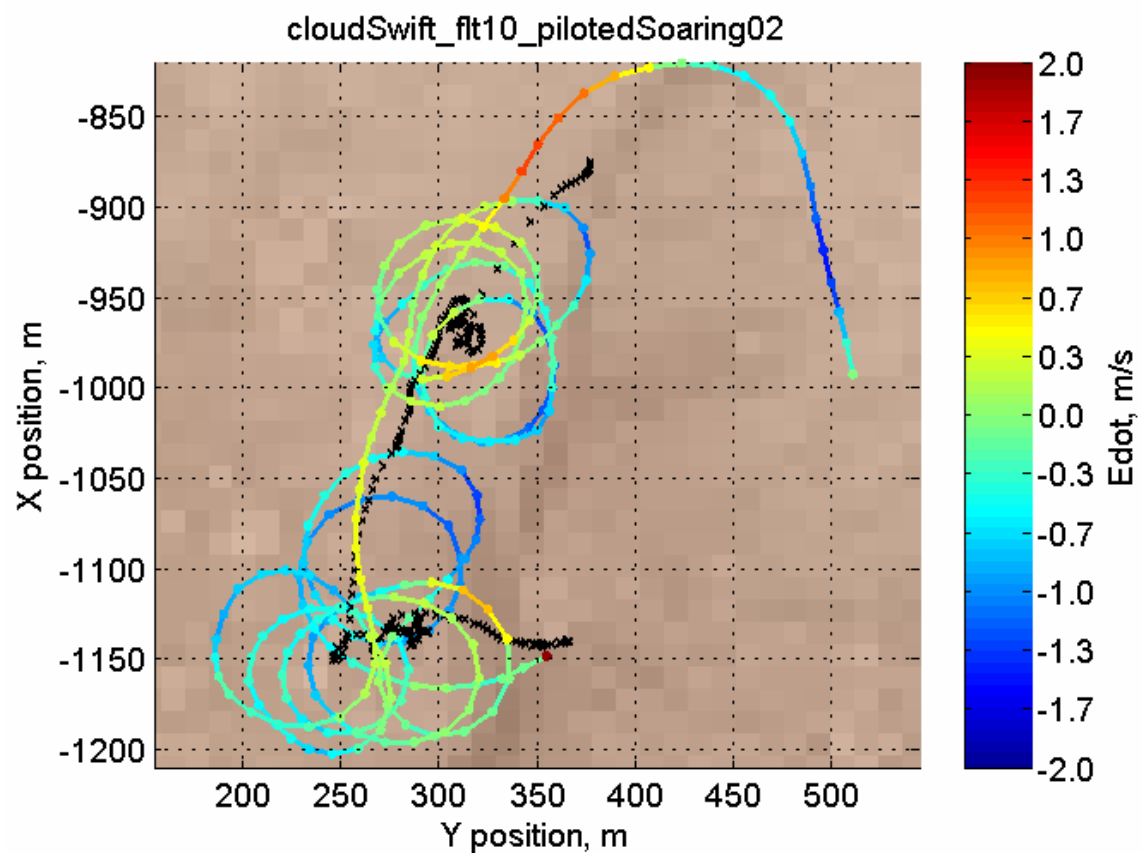
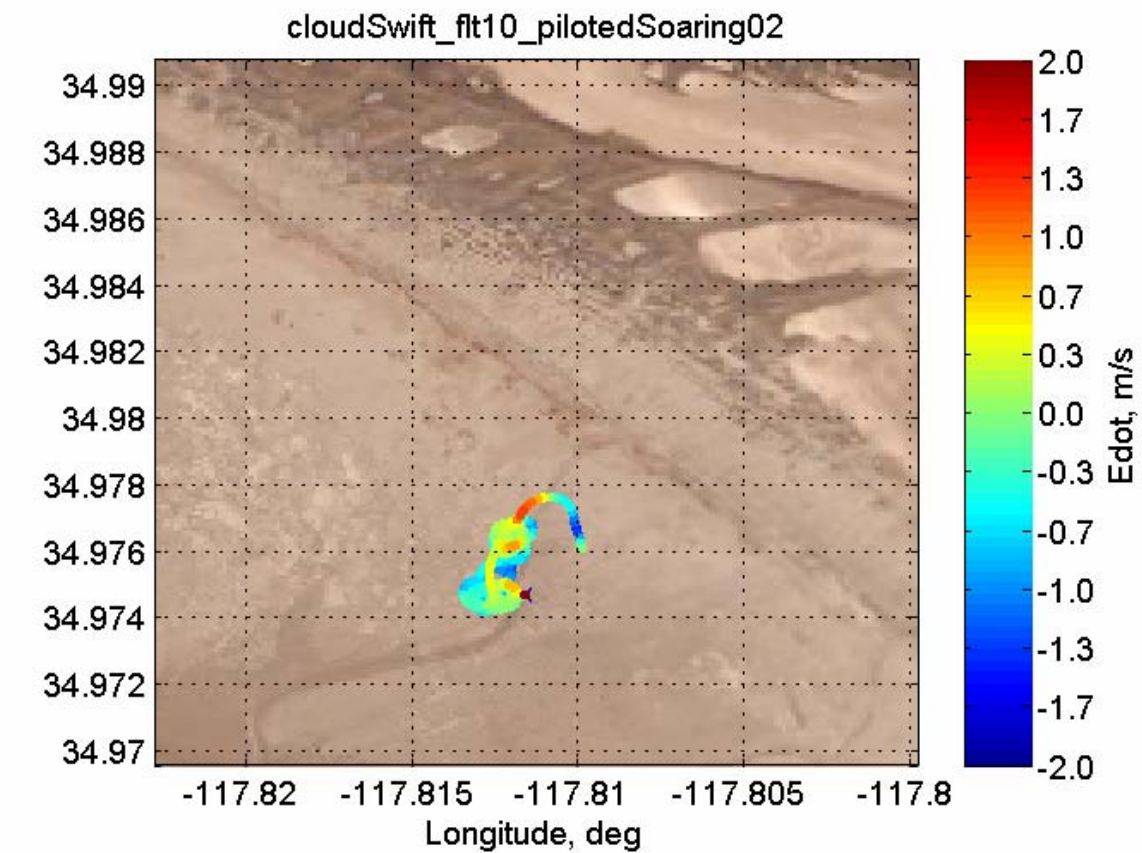


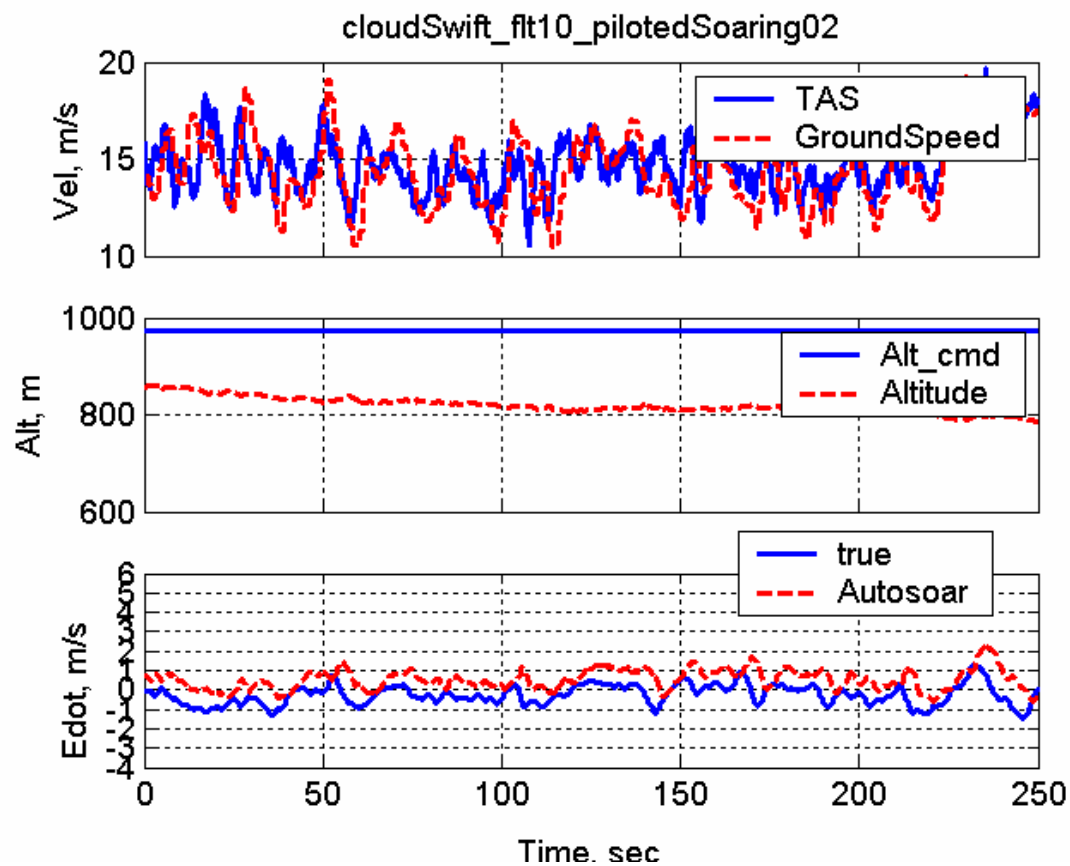
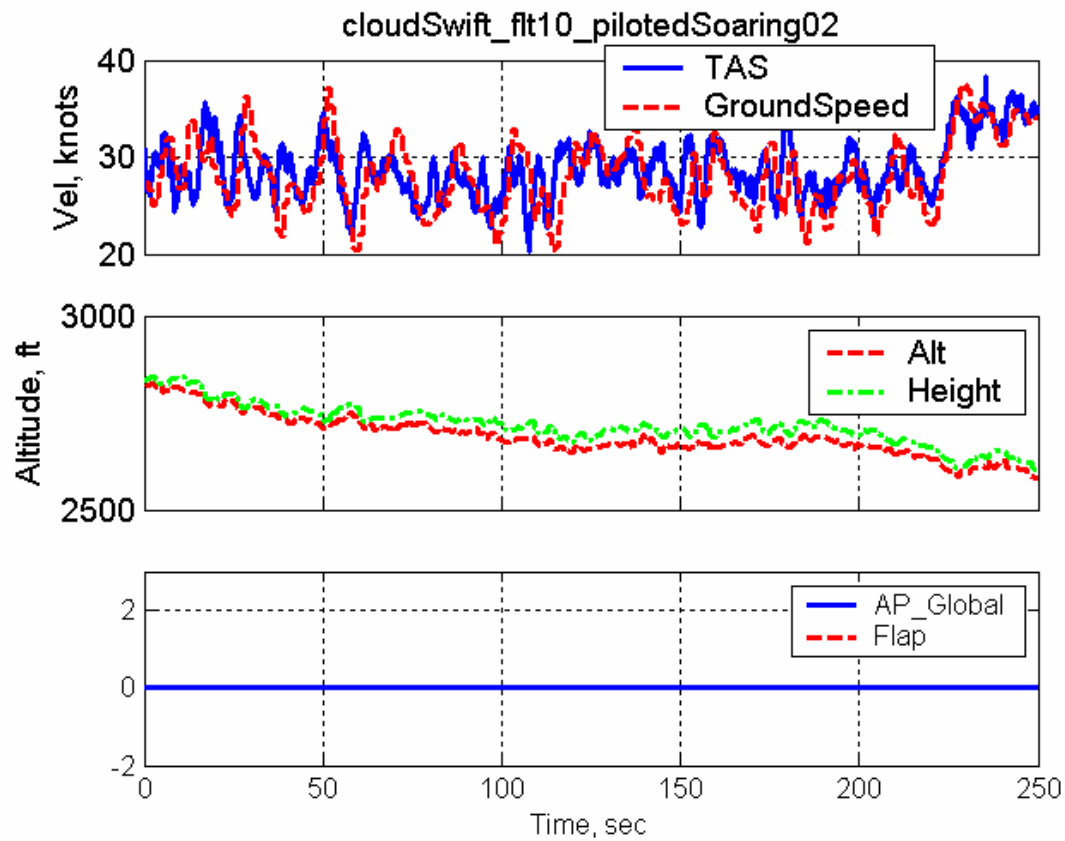


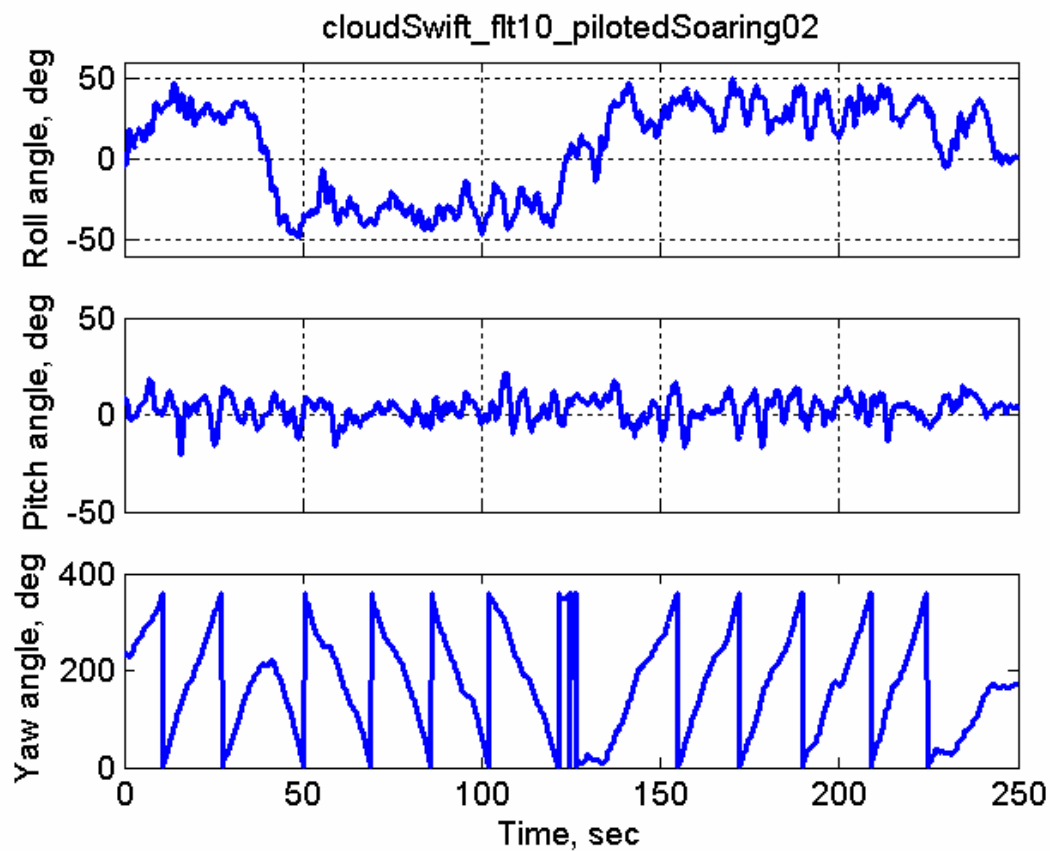
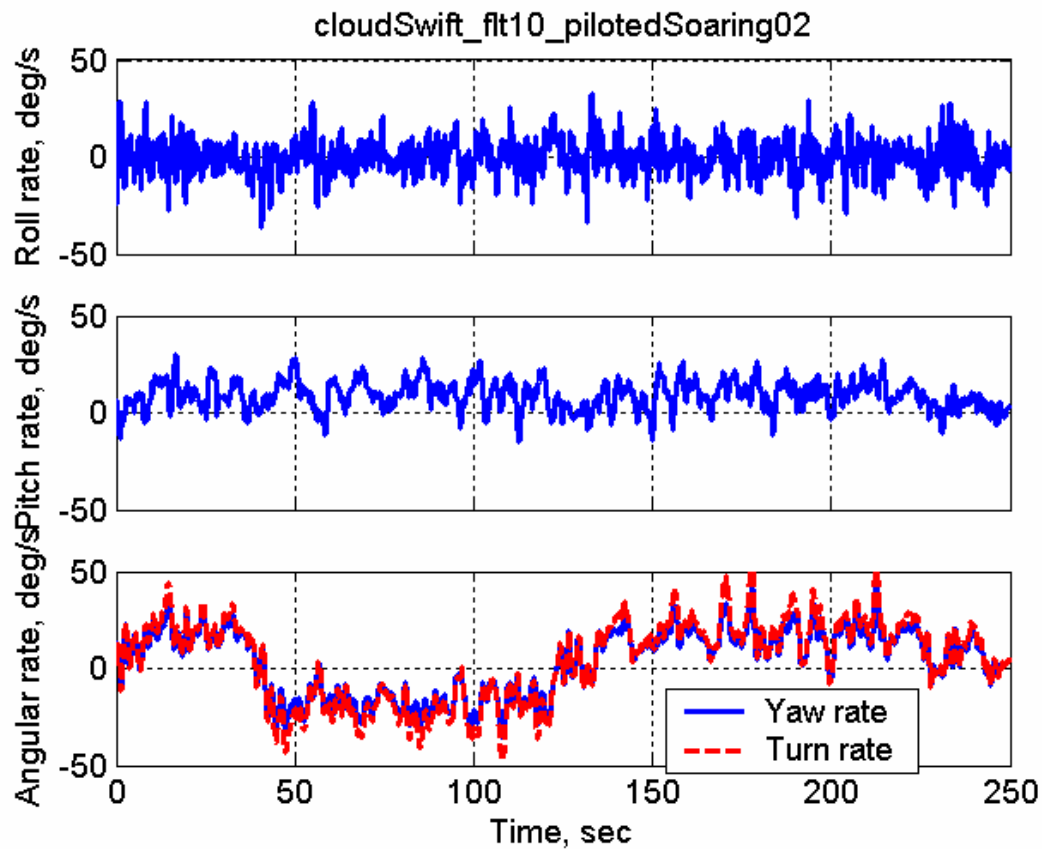
Flight 10, piloted soaring 2

Poor centering in light lift. Lift seems to get away.

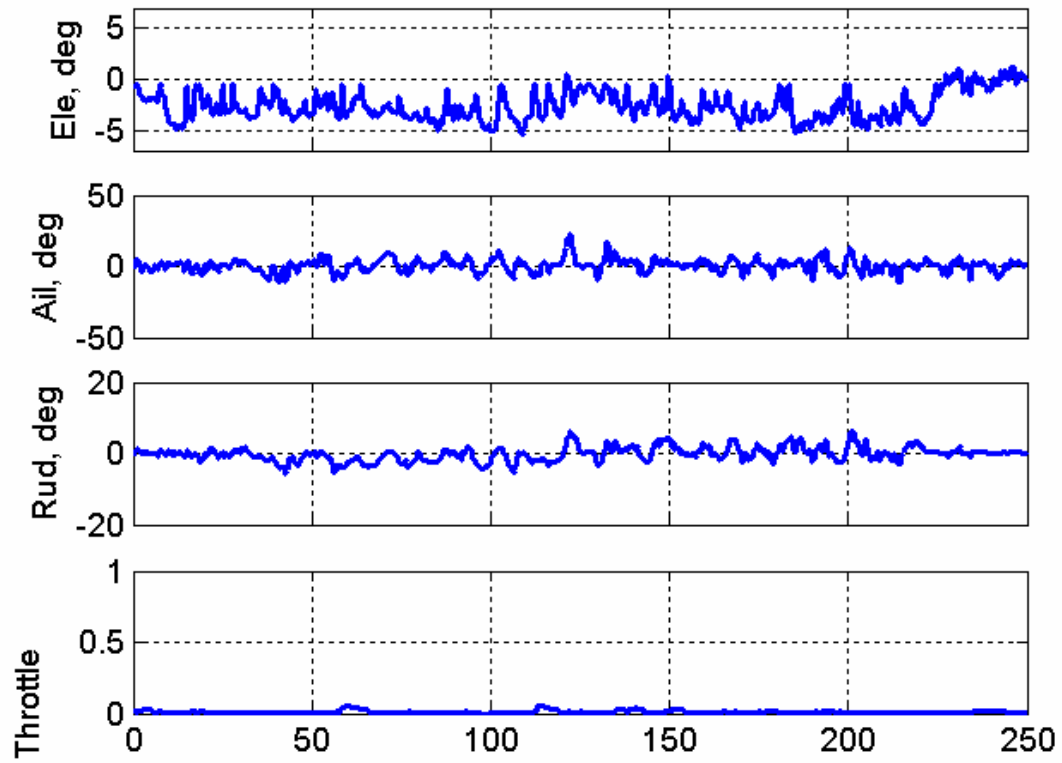




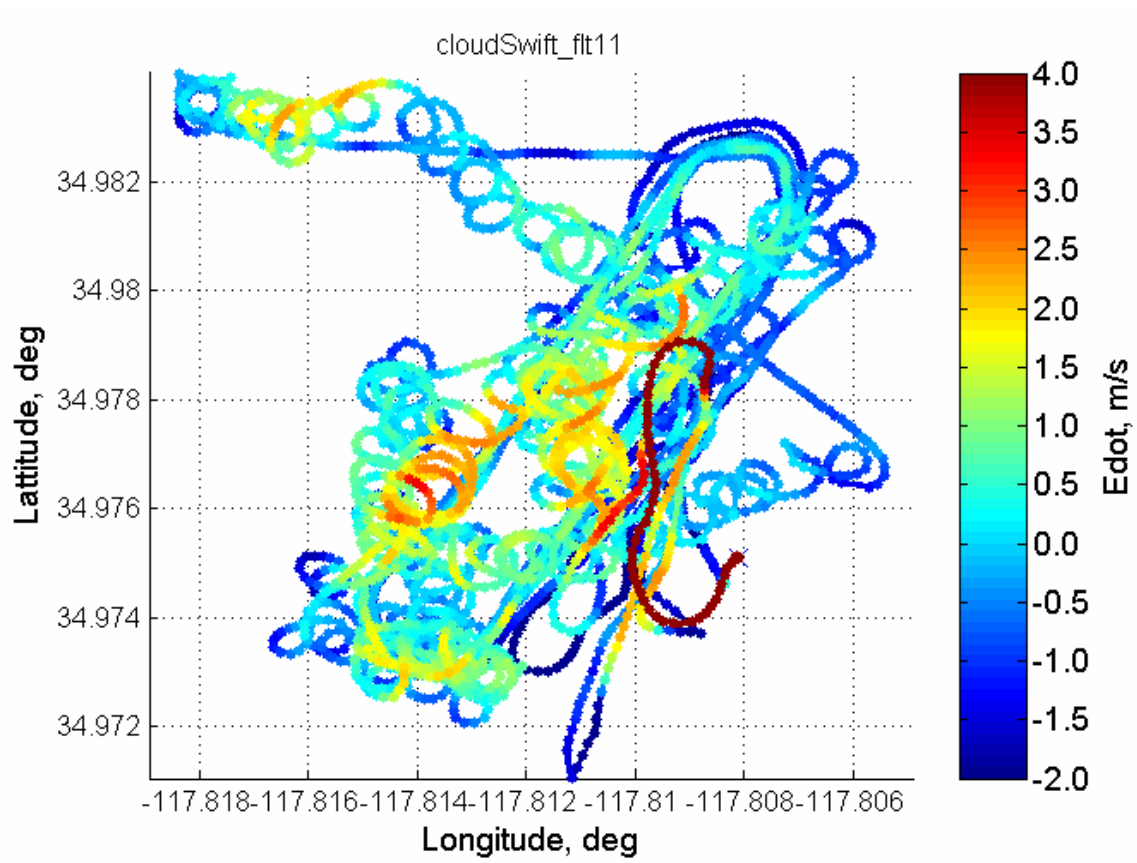


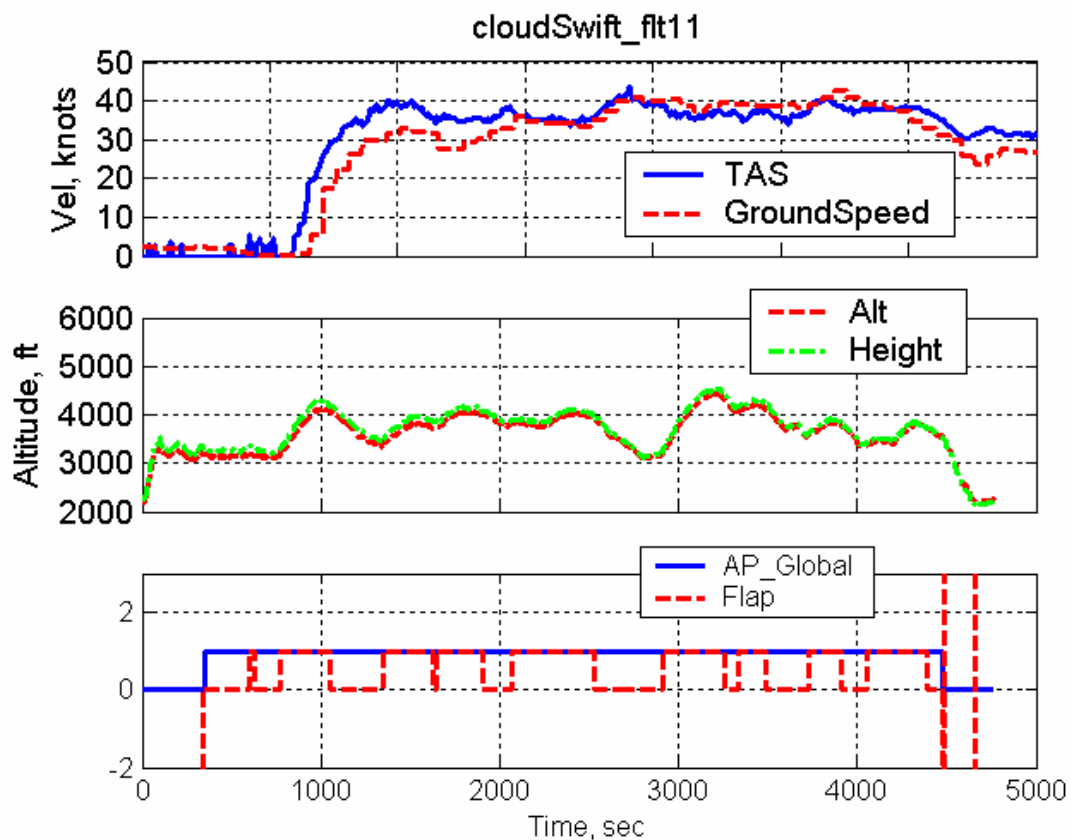
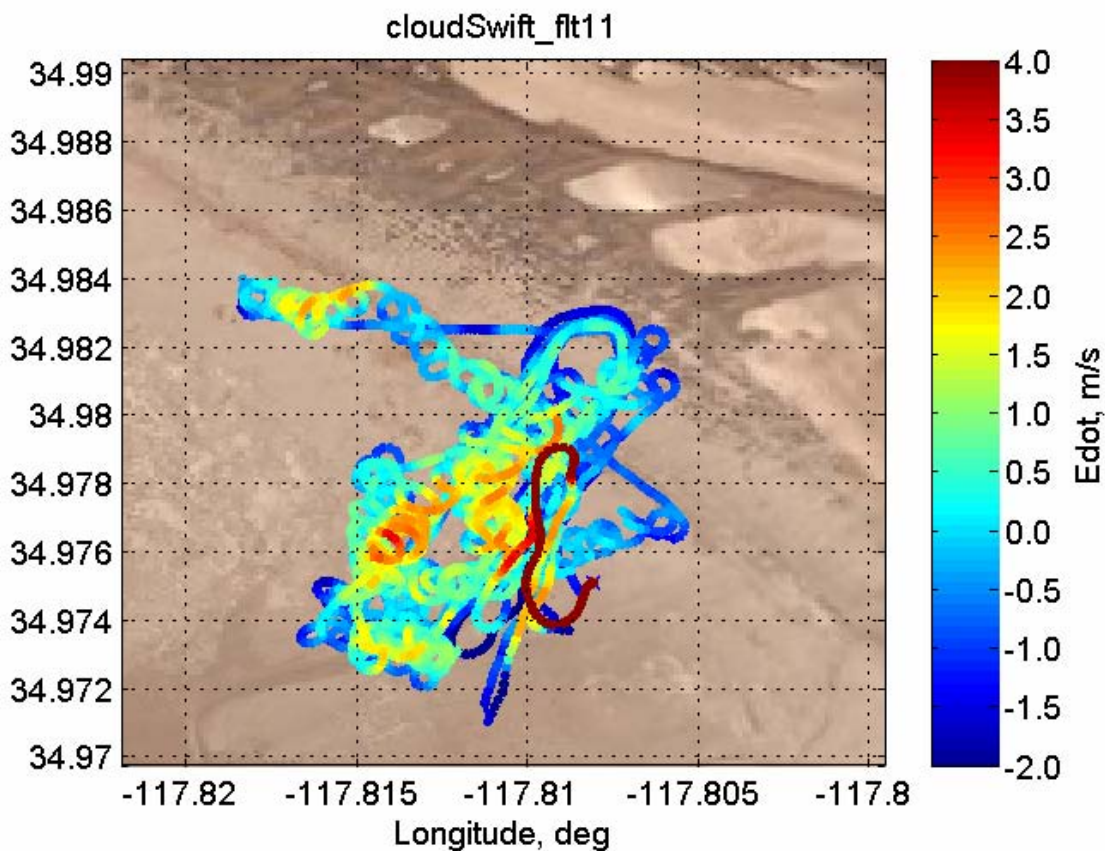


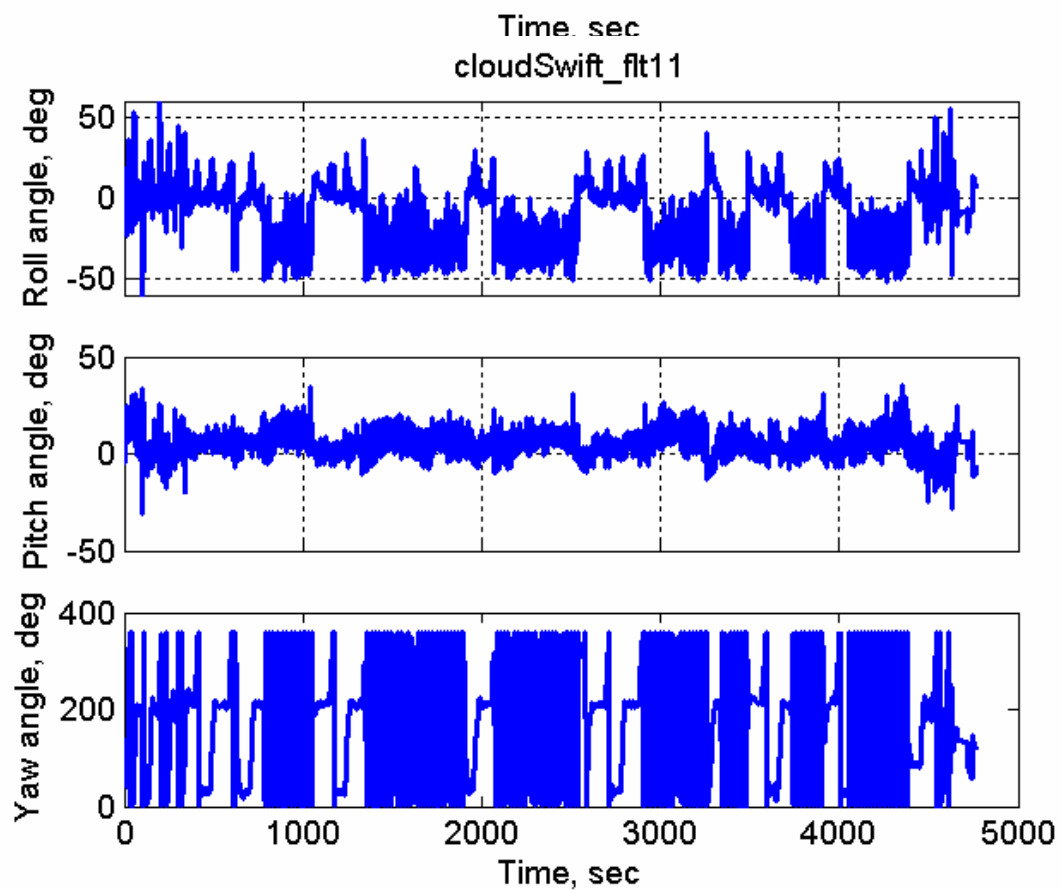
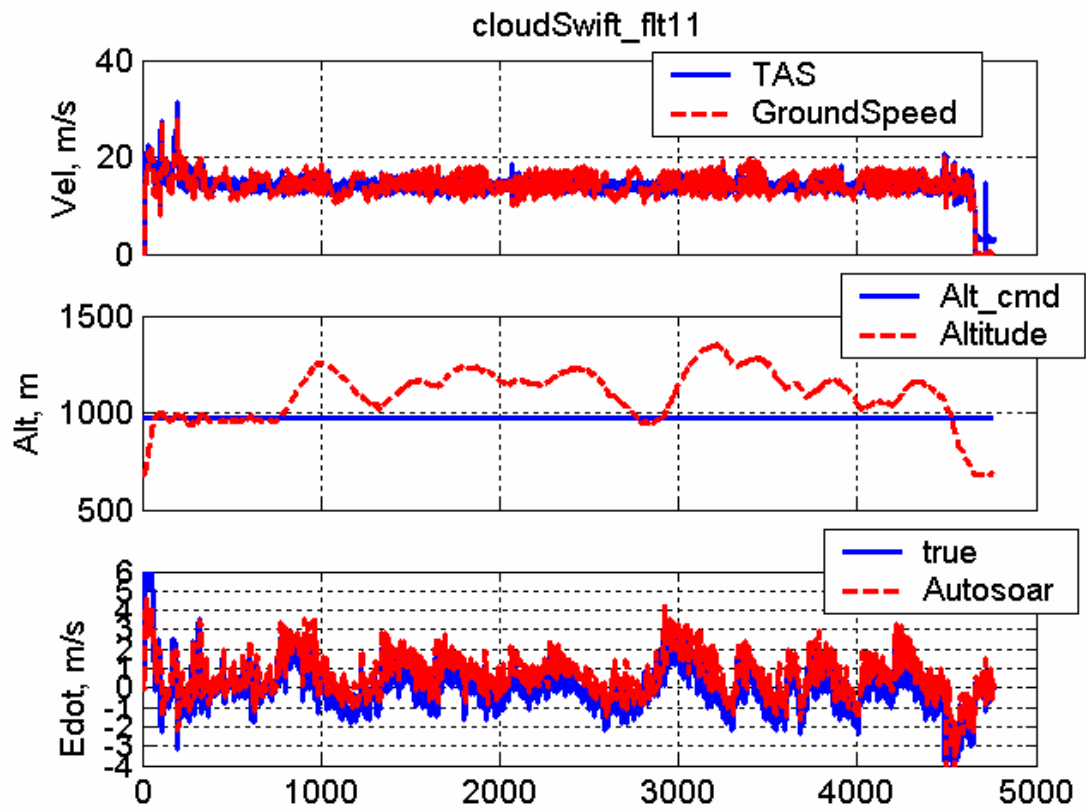
cloudSwift_flt10_pilotedSoaring02

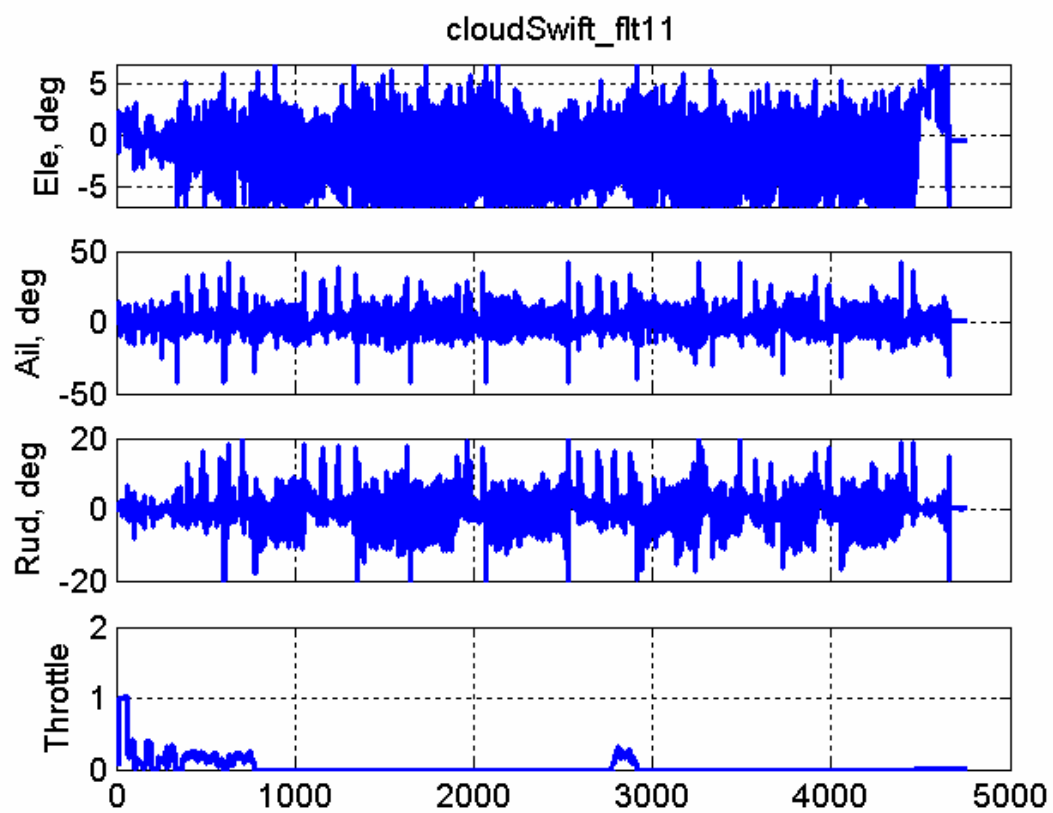


Flight 11



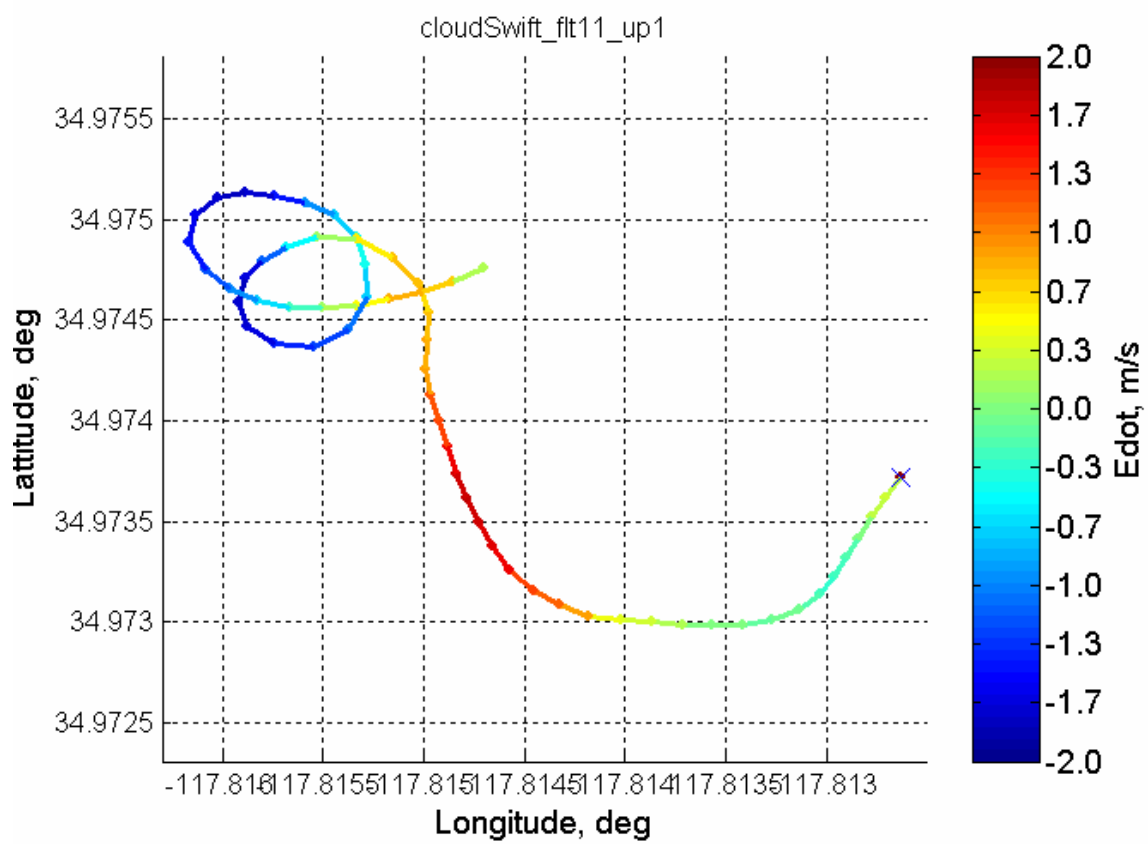


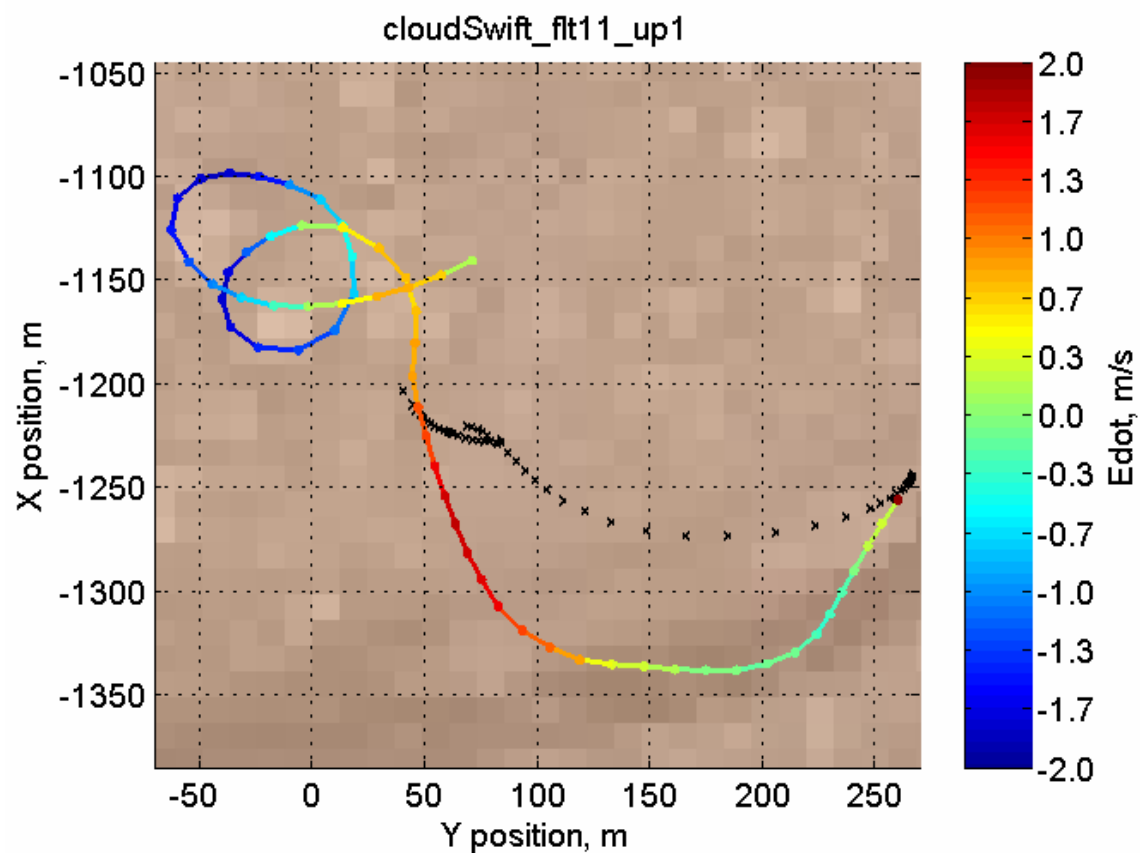
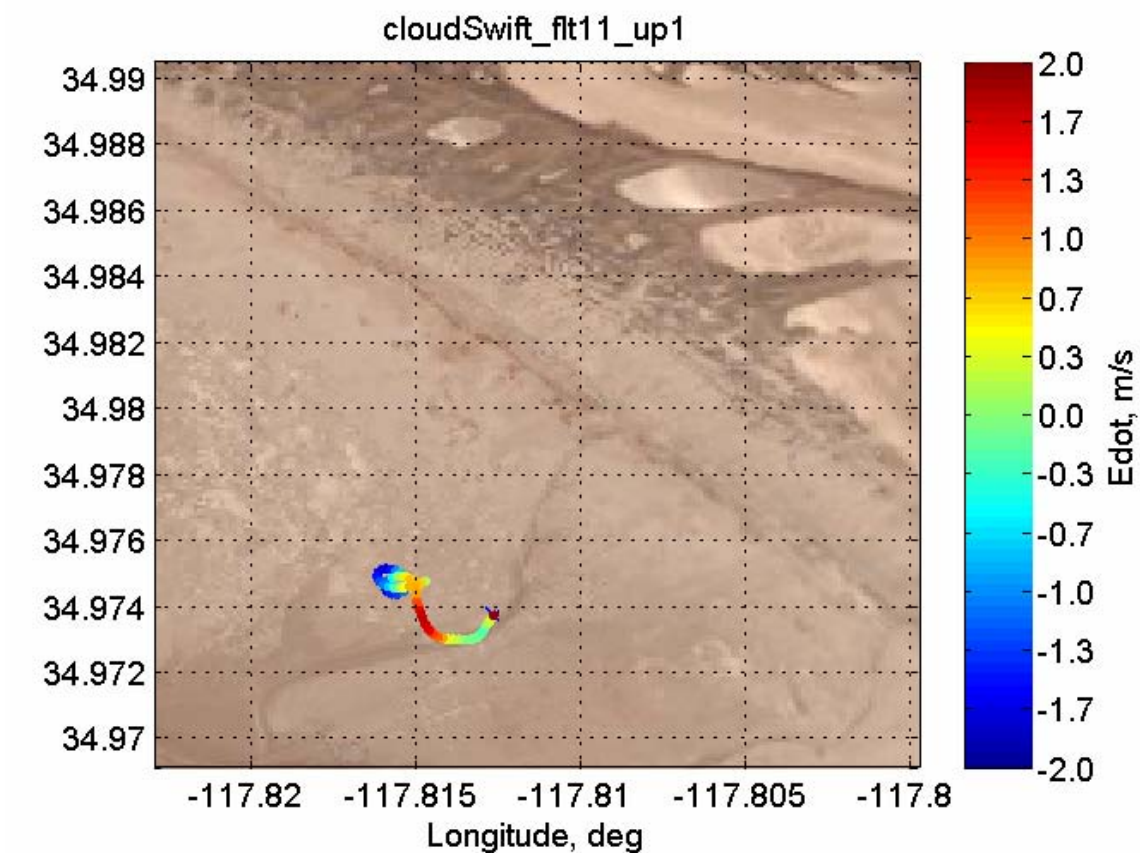


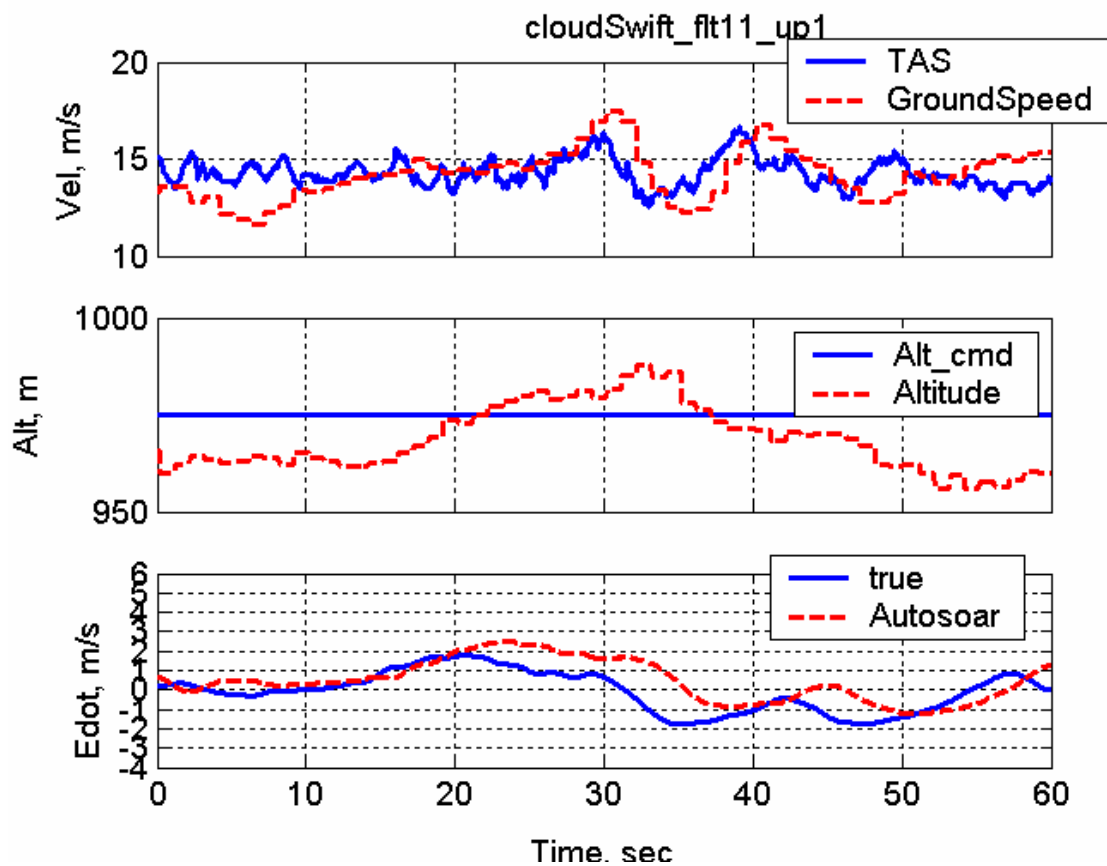
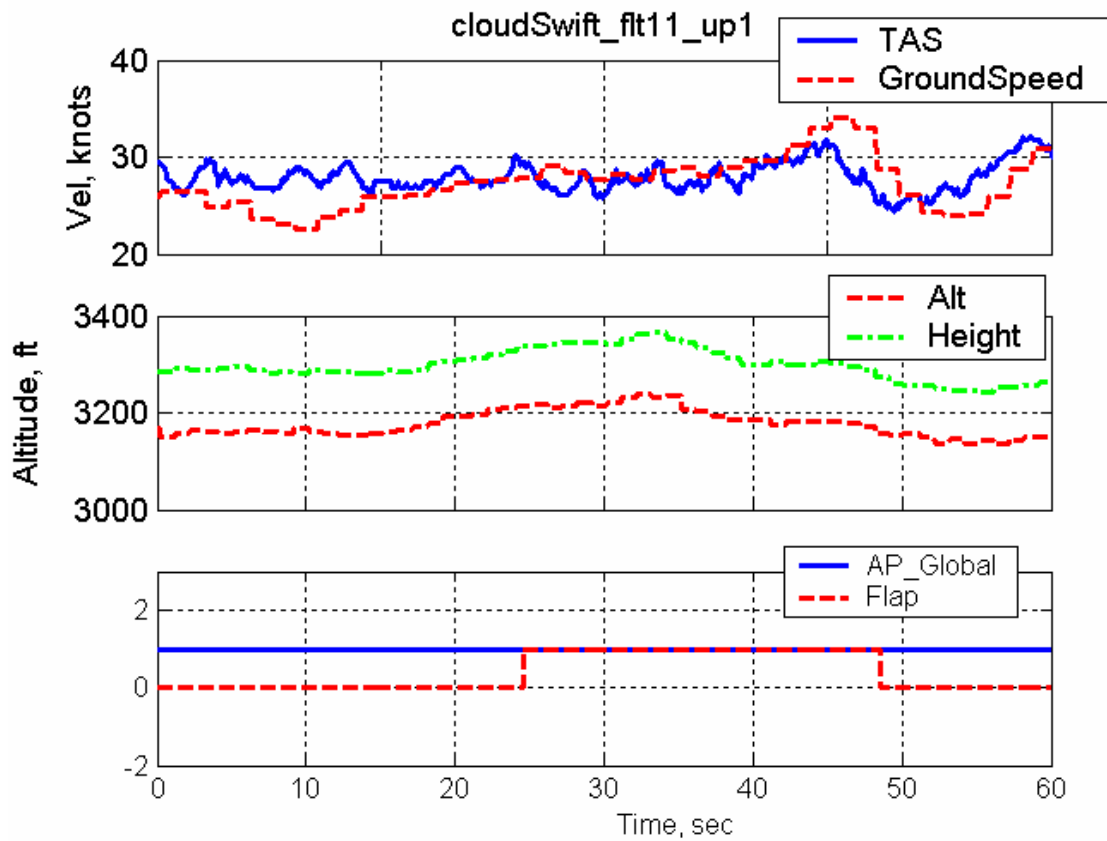


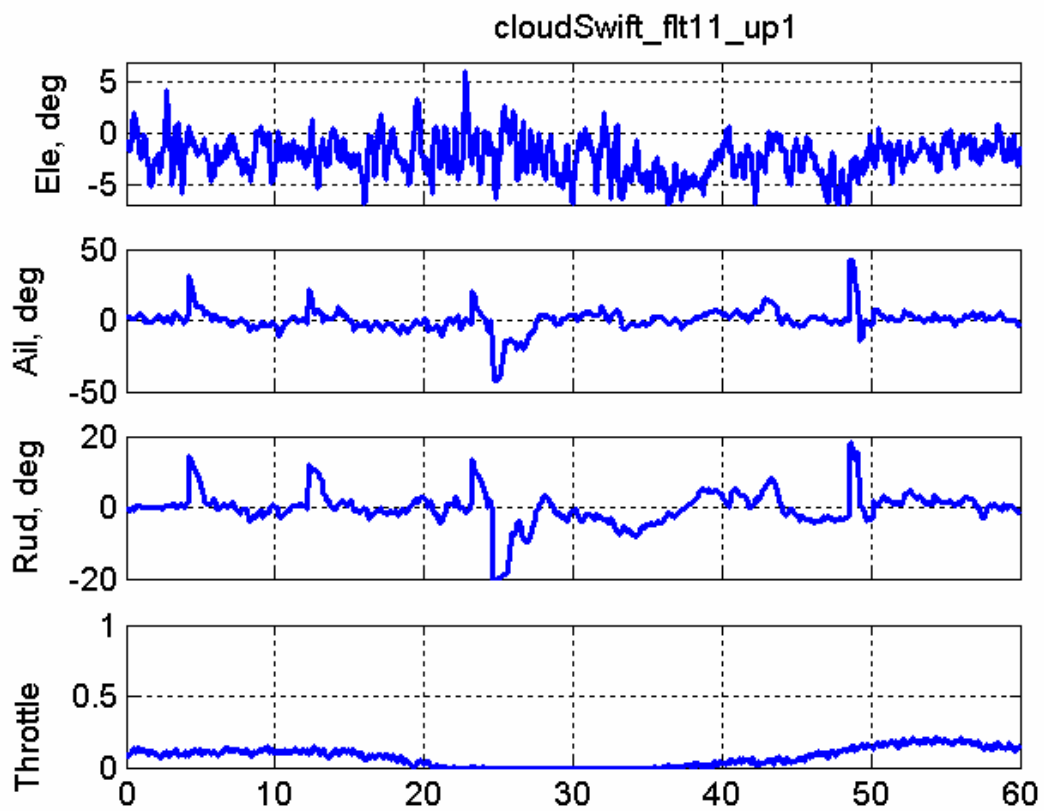
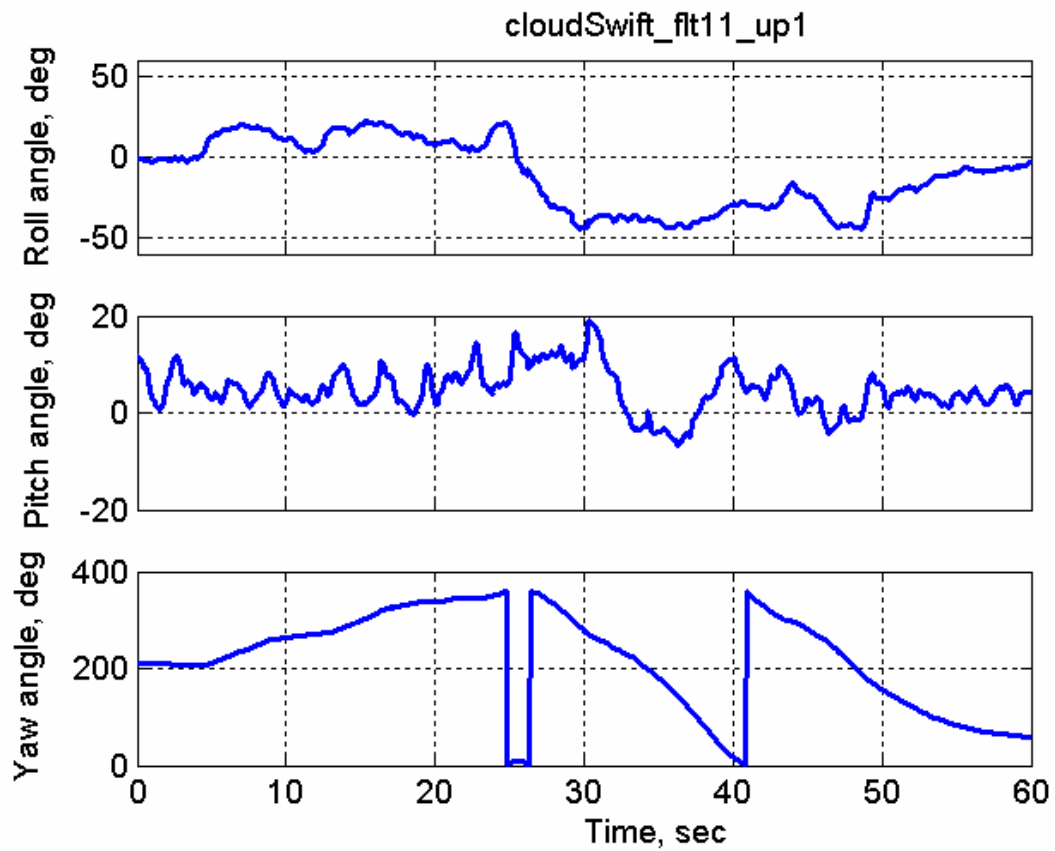
Flight 11, updraft 1

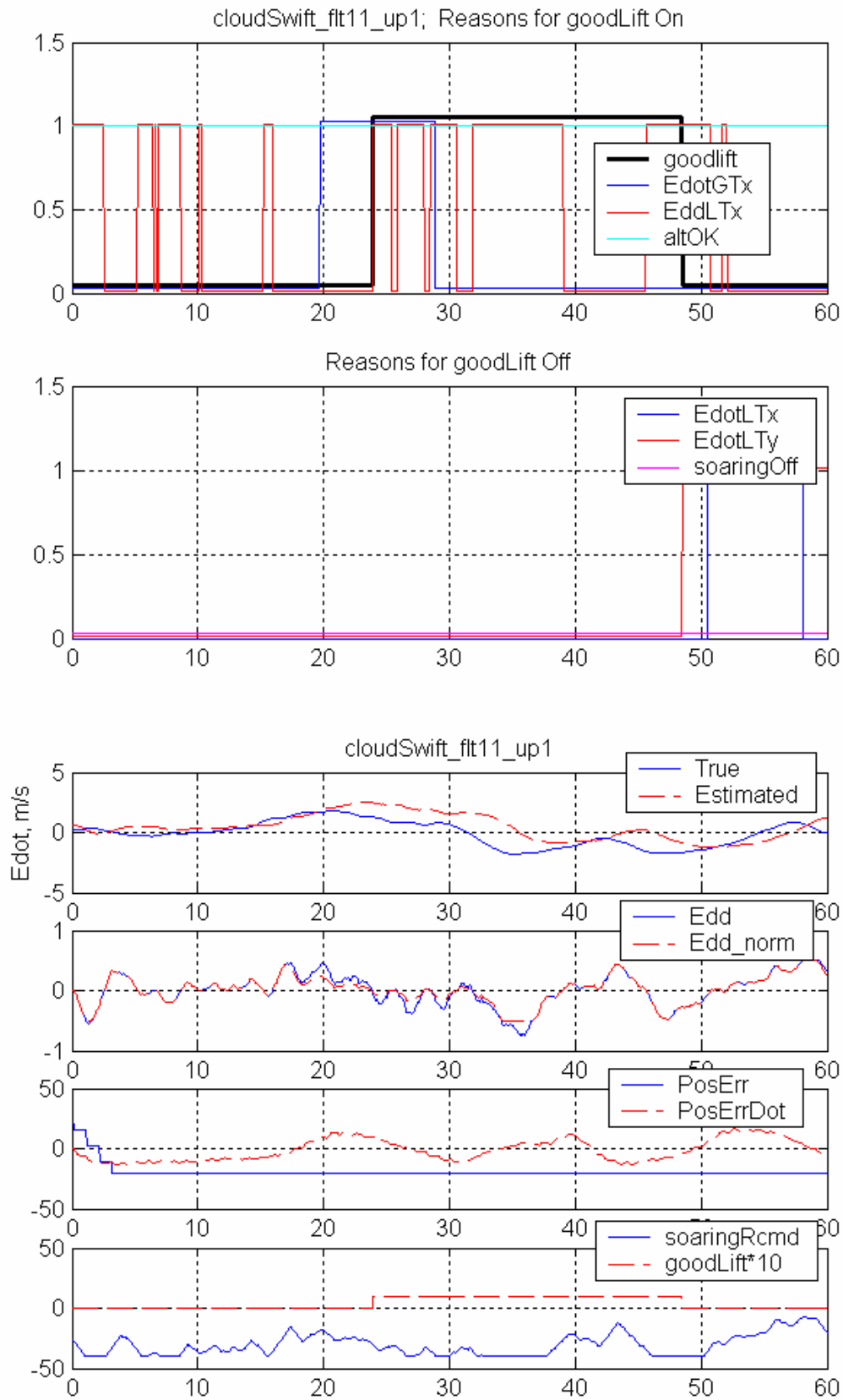
Very short. Shows controller performance well. Never gets back to center because Edd gain too high.

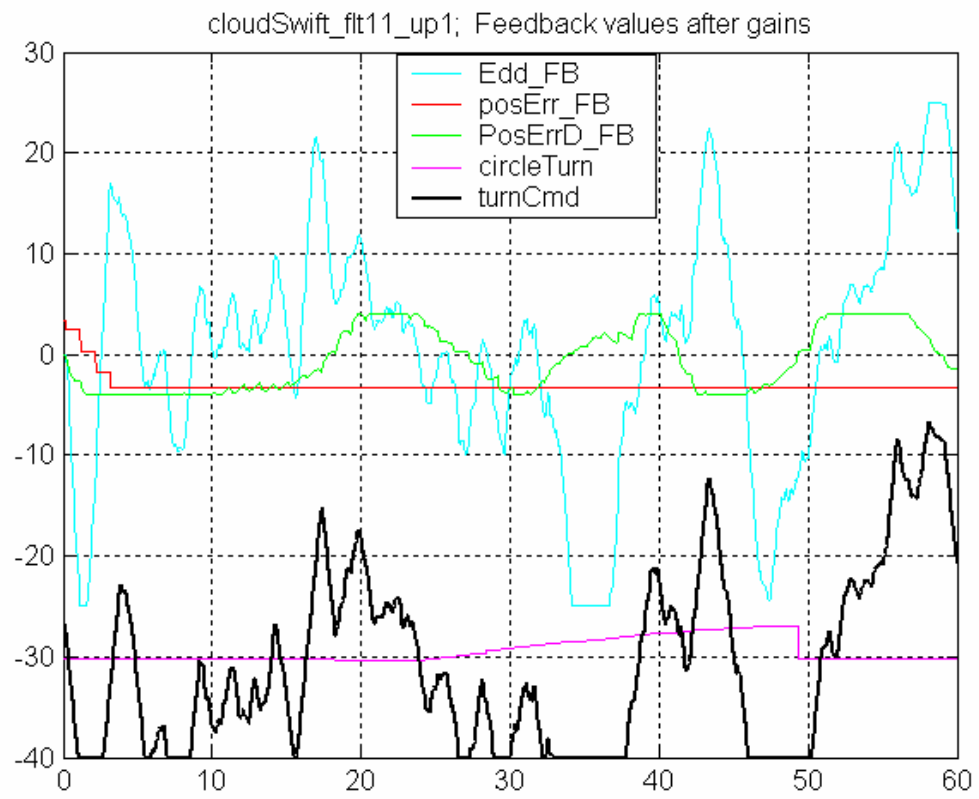






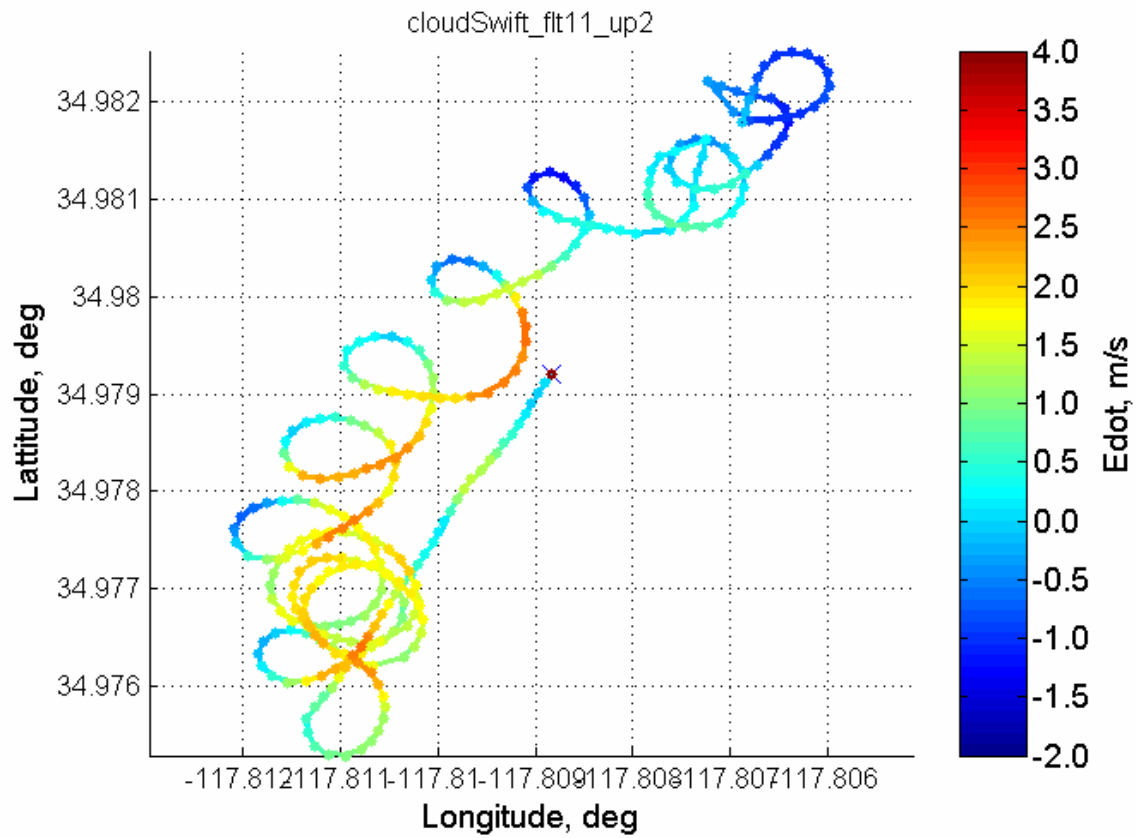


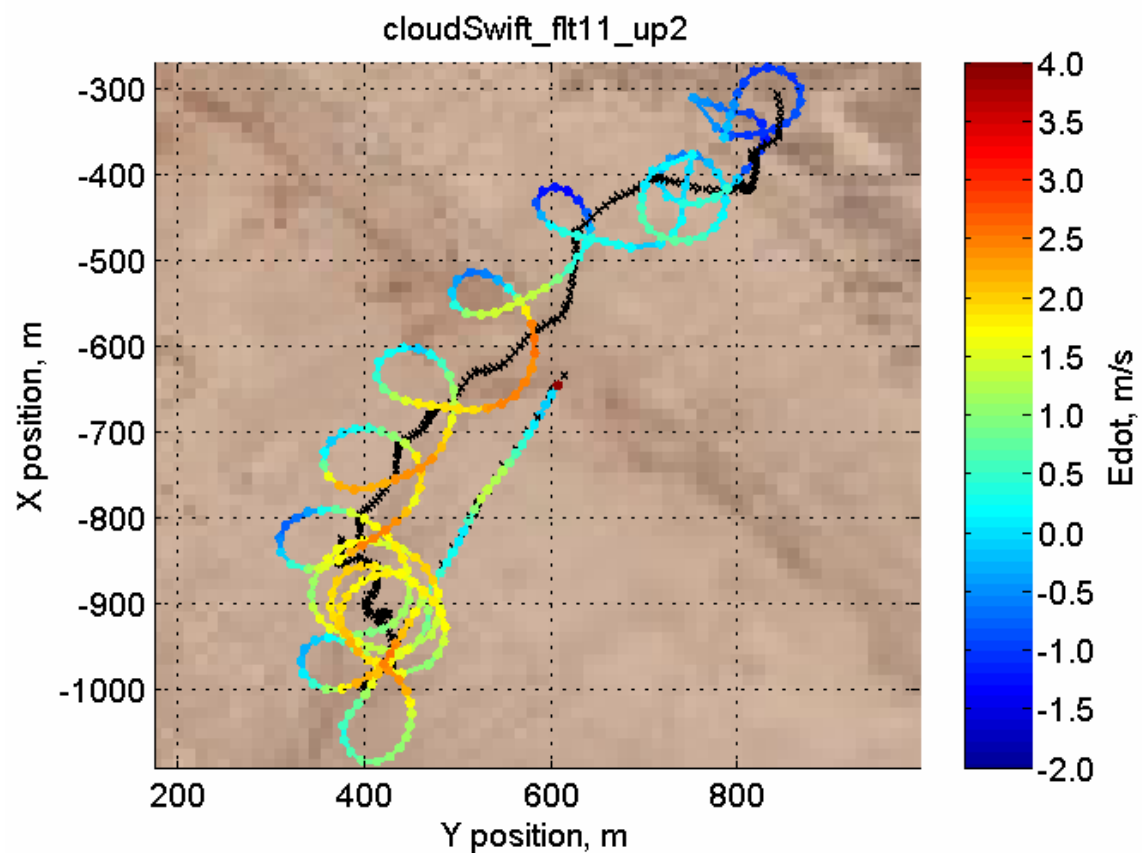
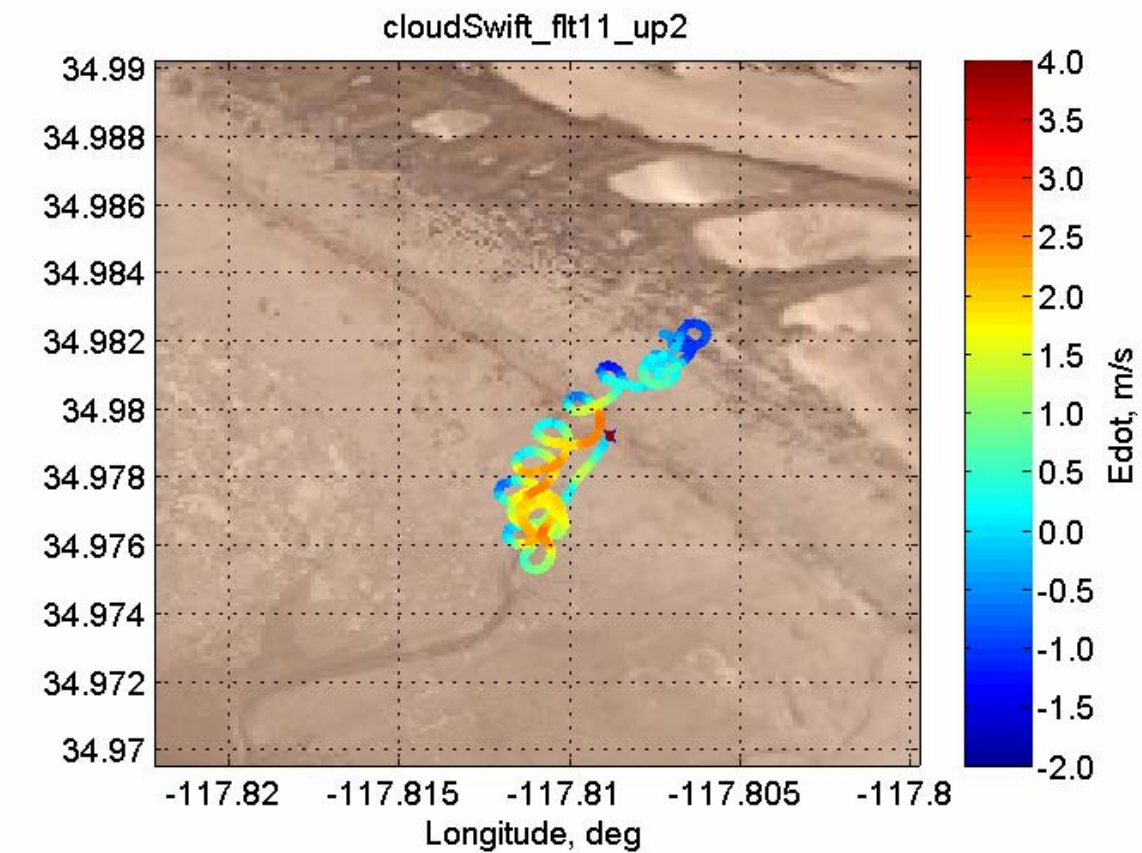


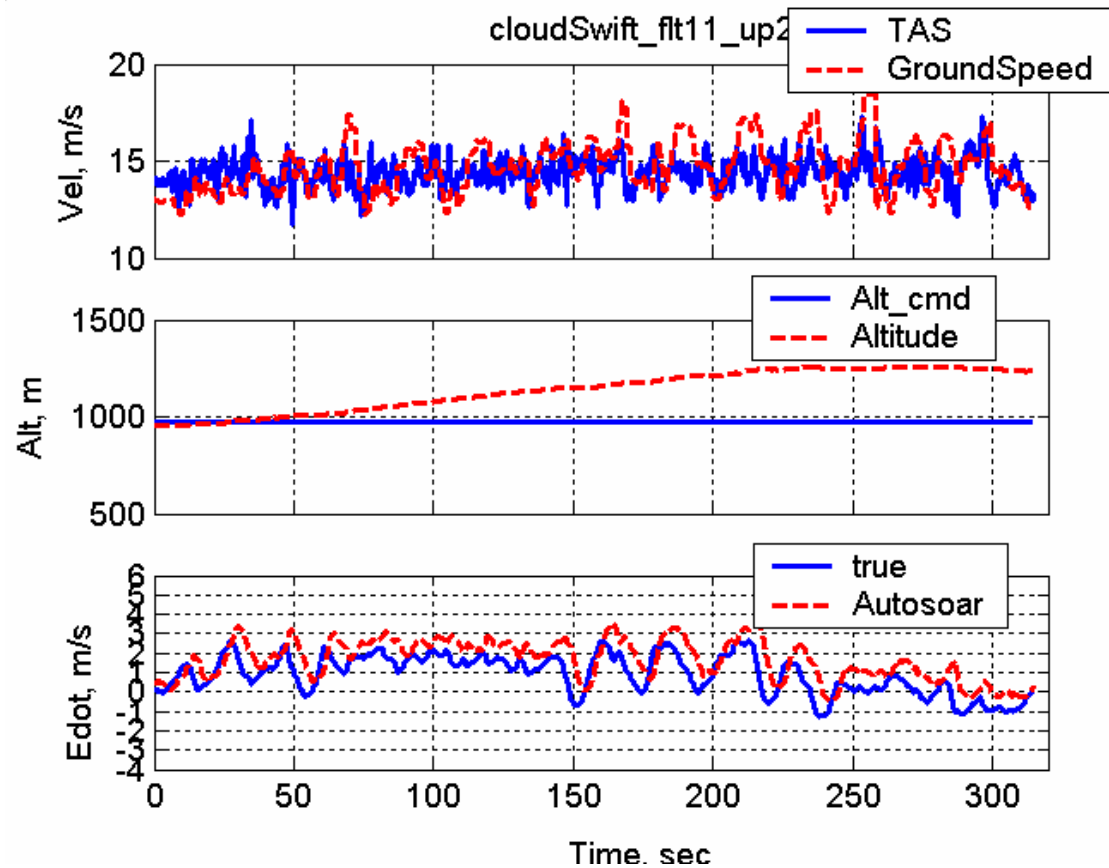
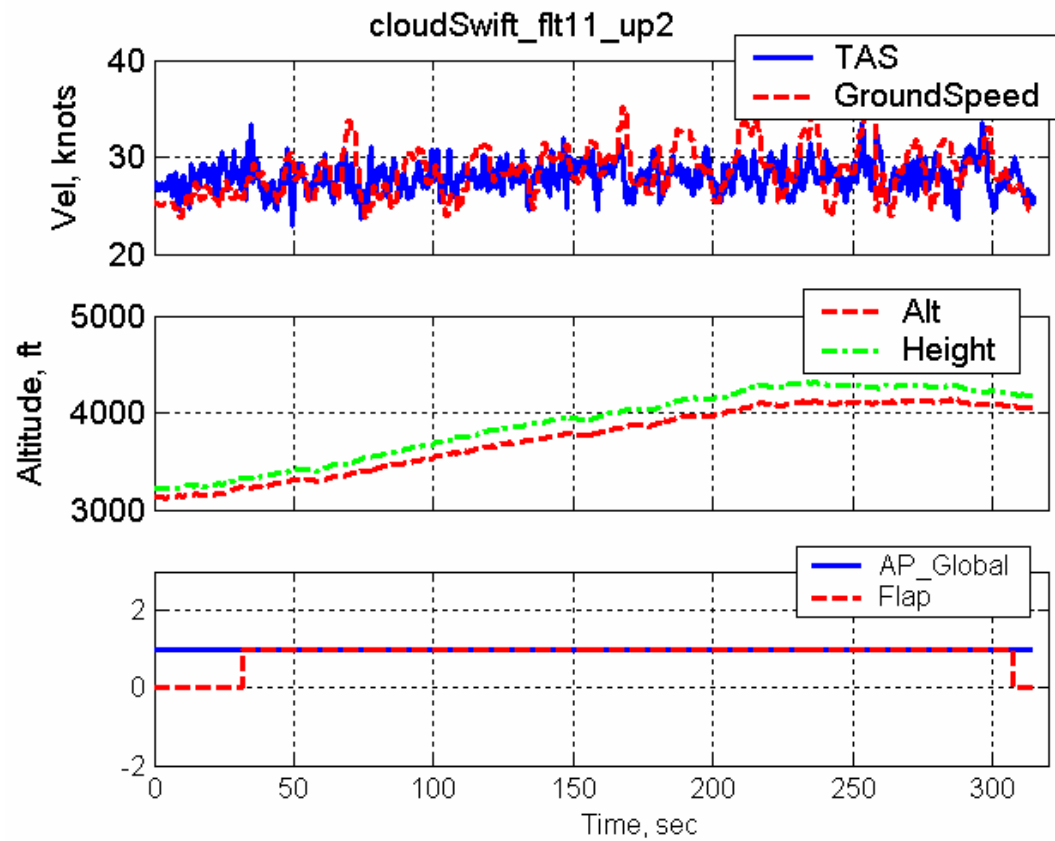


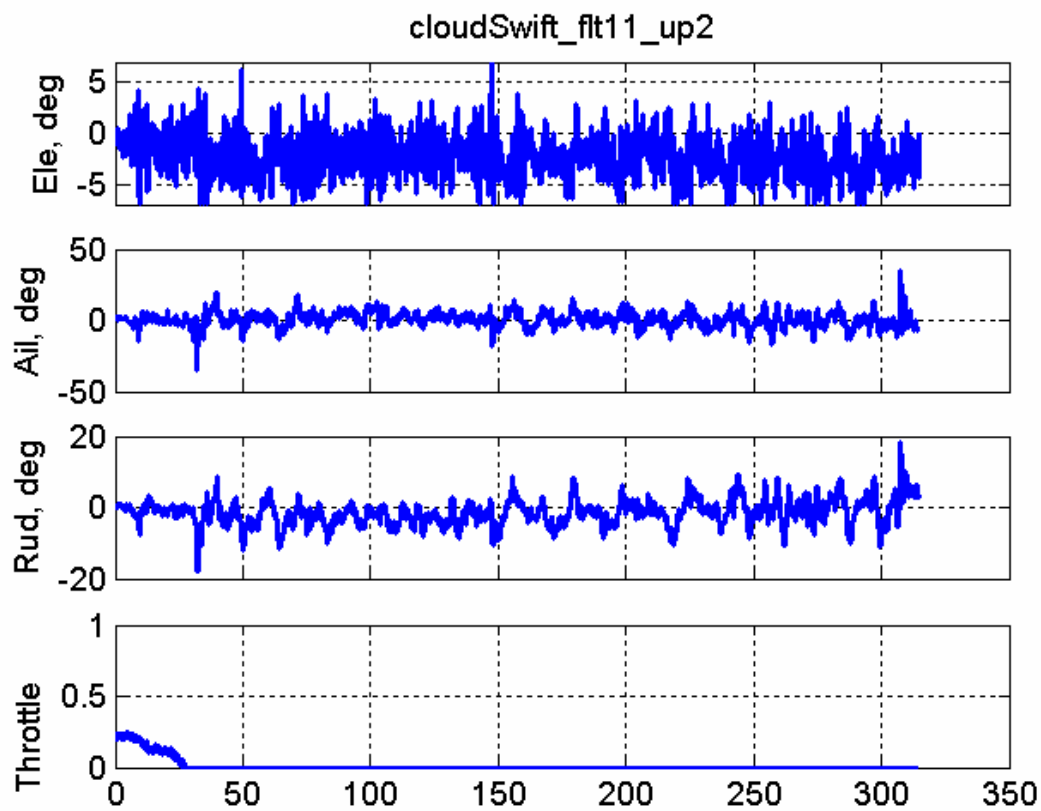
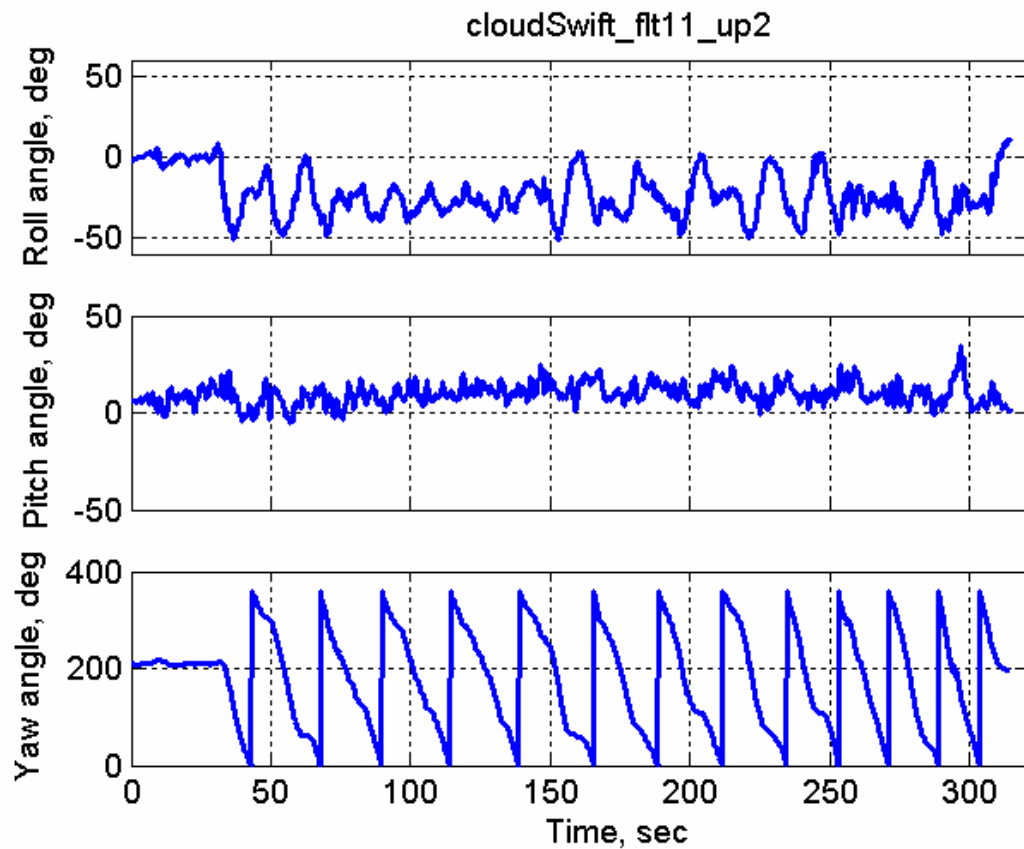
Flight 11, updraft 2

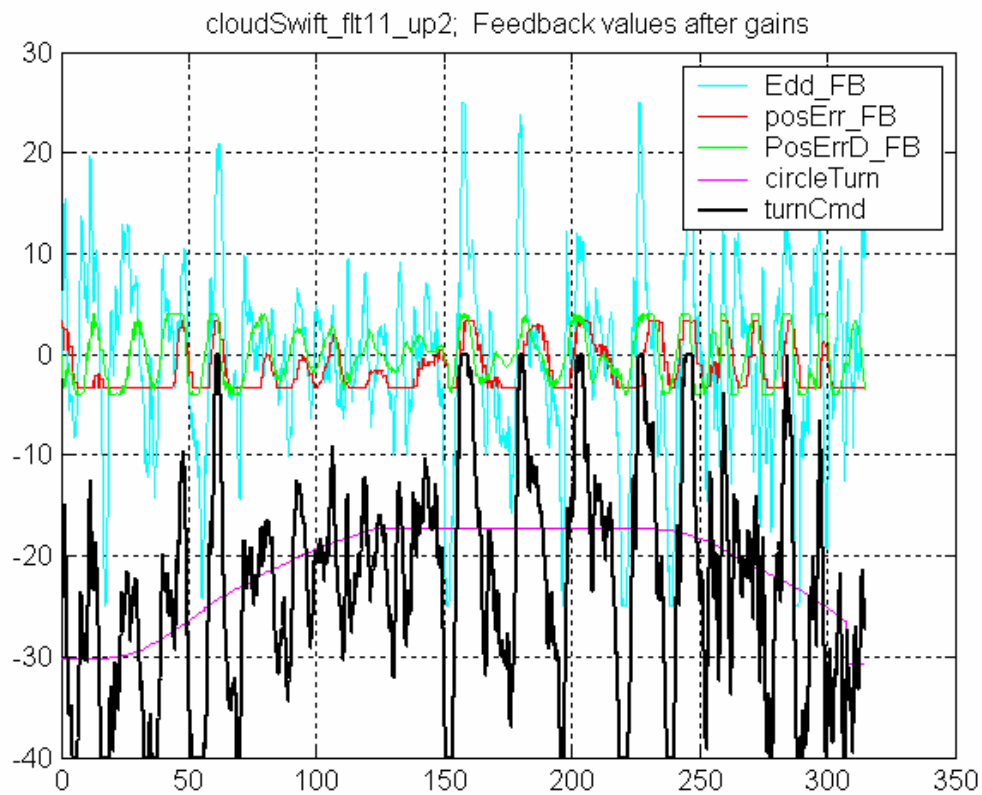
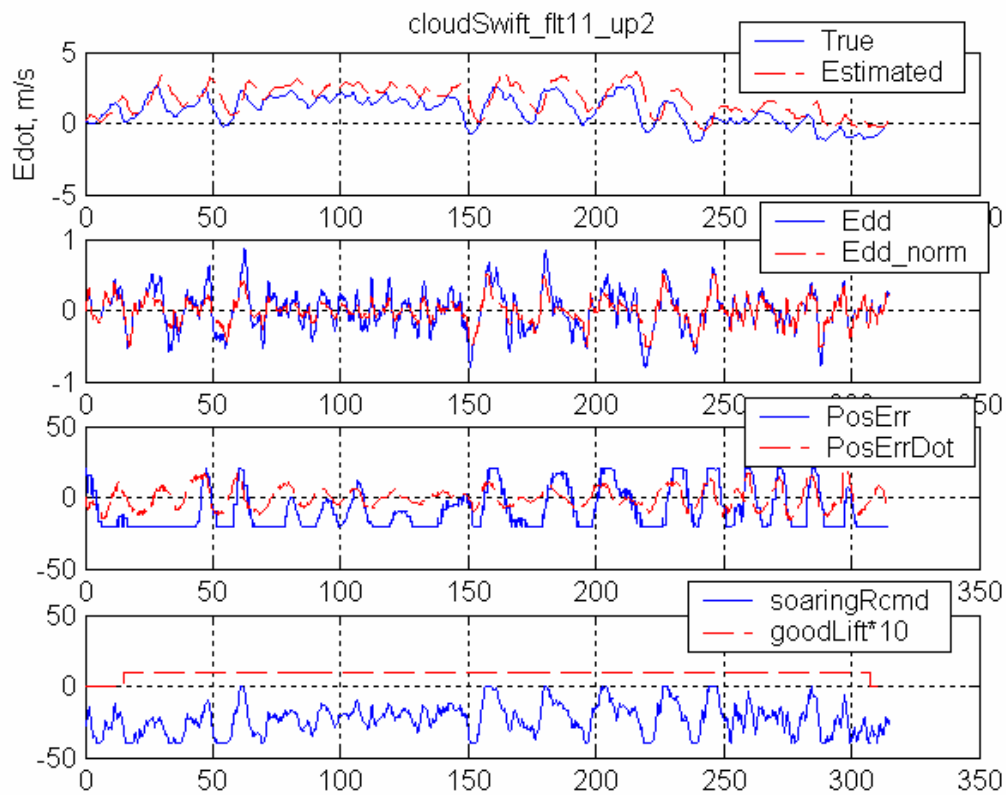
Good. 1000' climb. high drift. Excellent match of updraft shape.

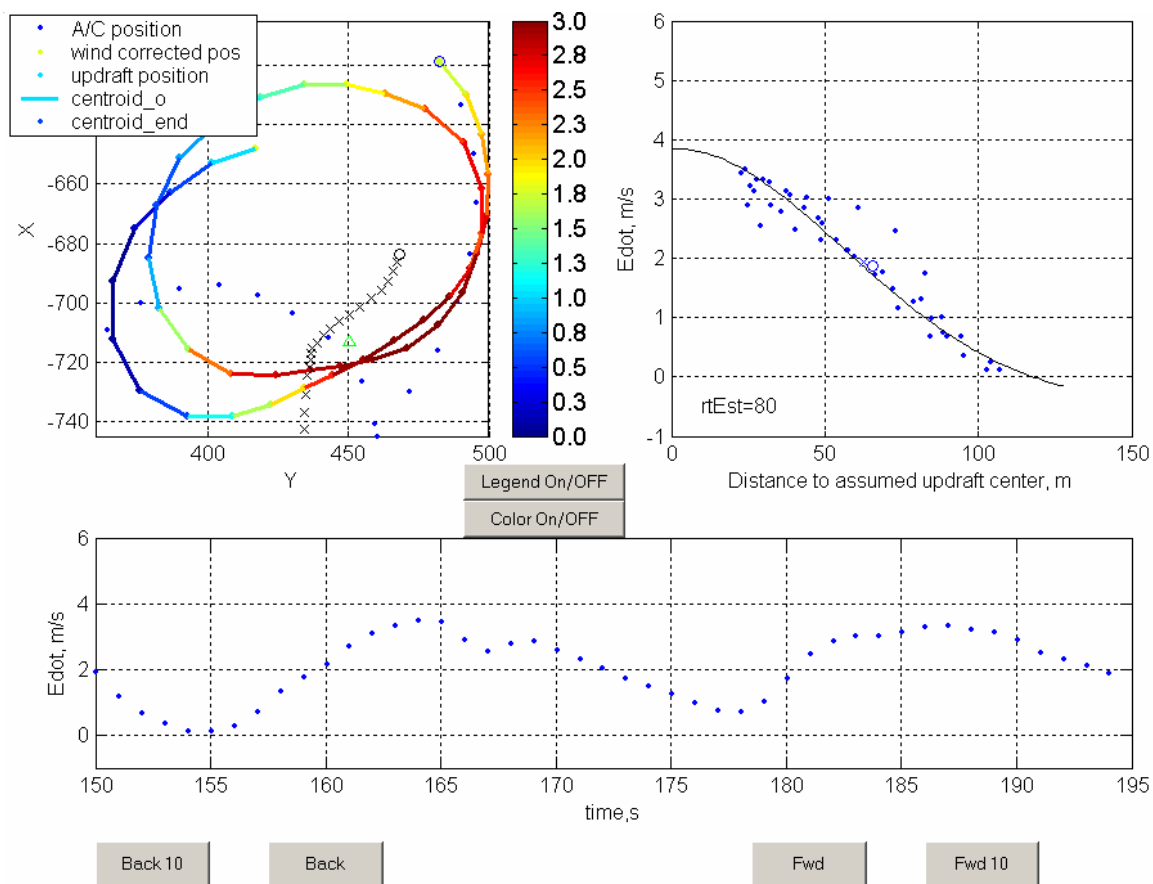






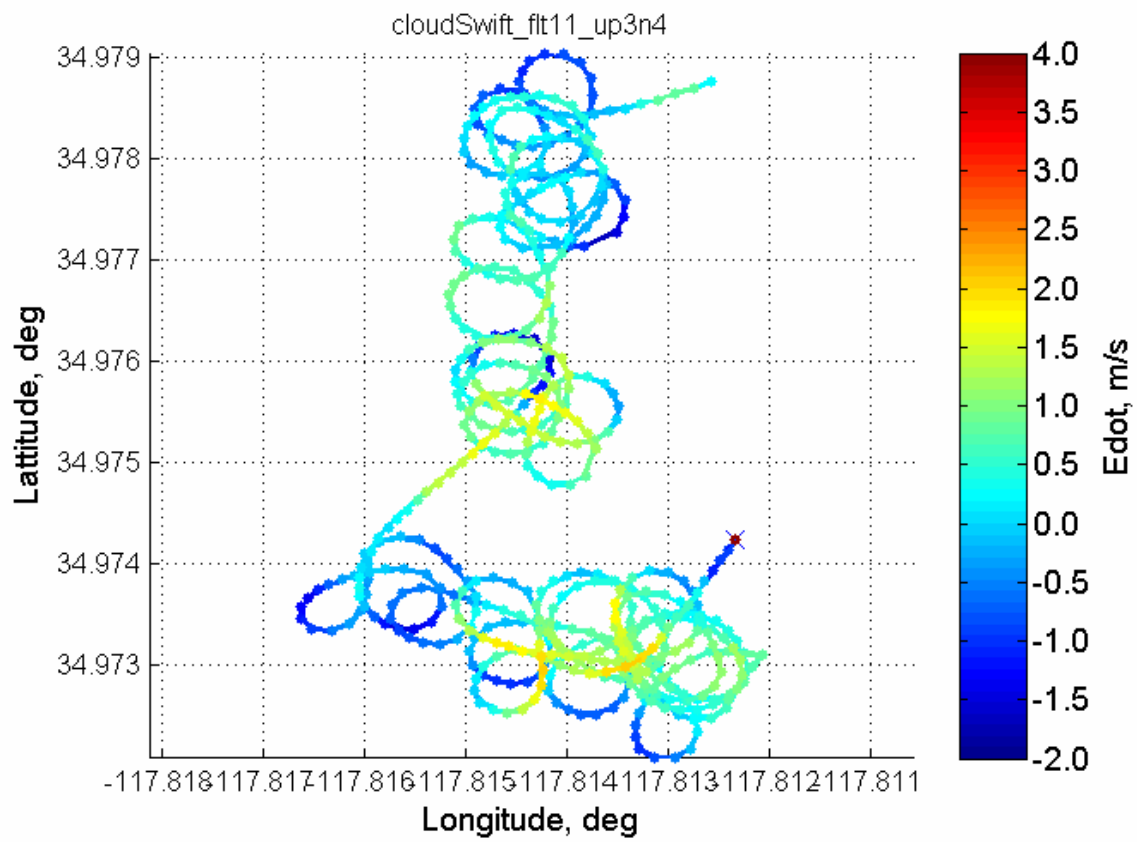


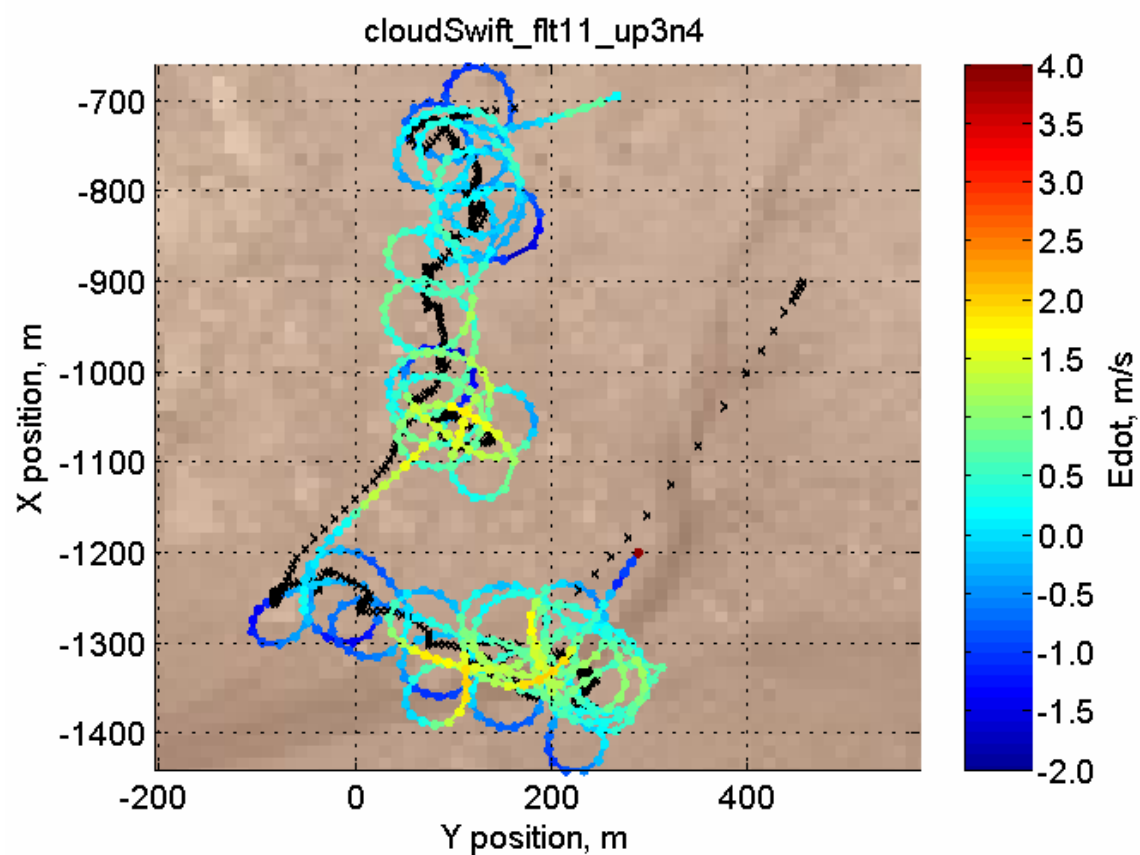
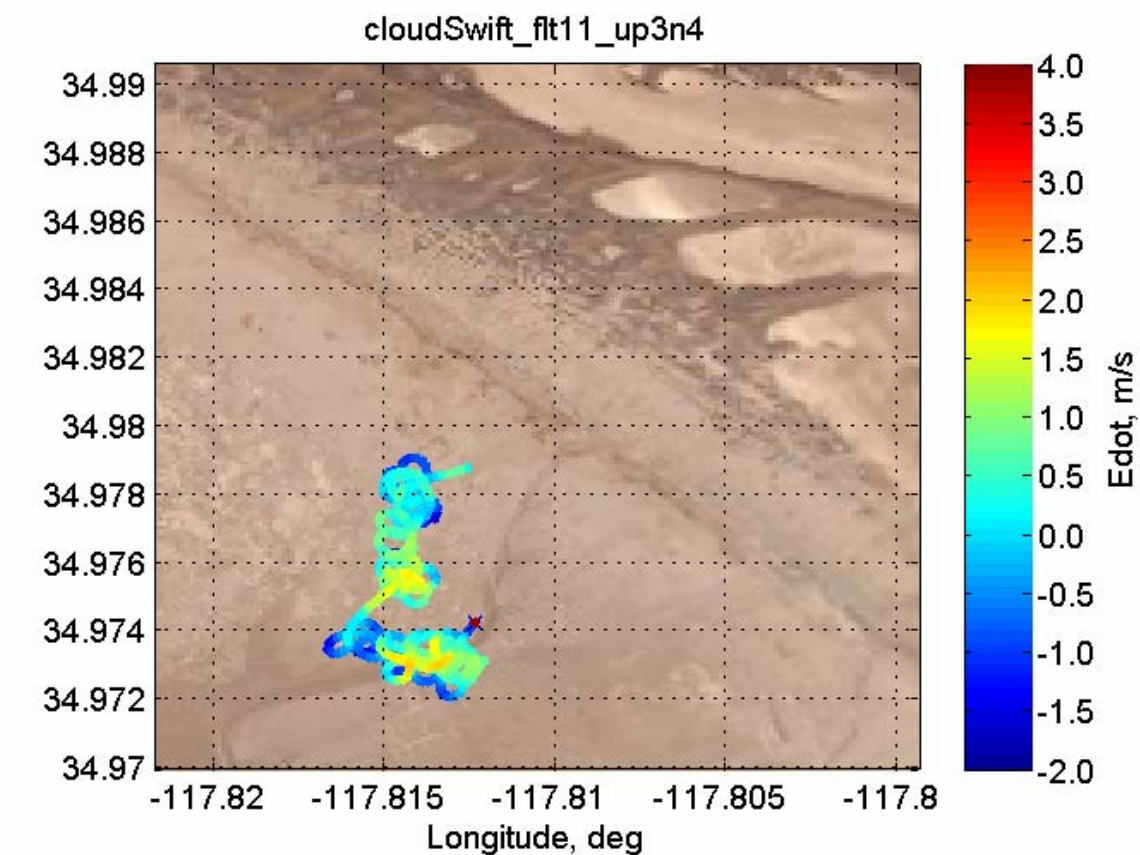




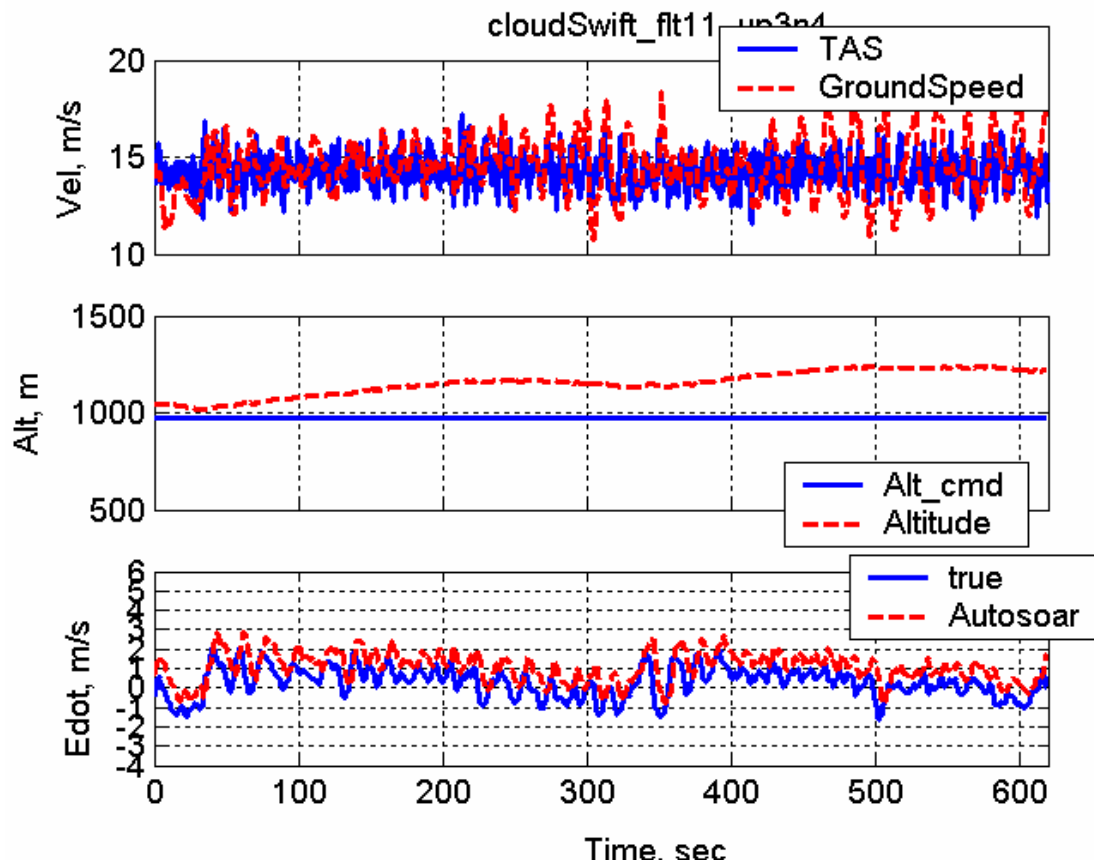
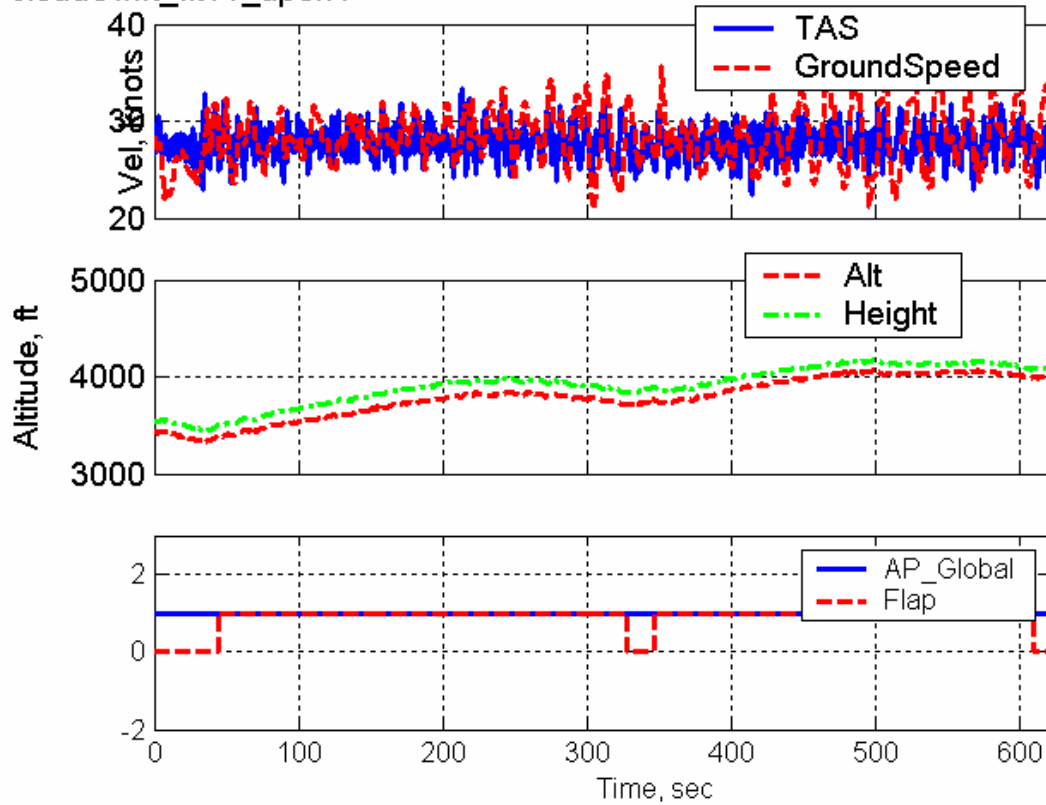
Flight 11, updrafts 3 and 4

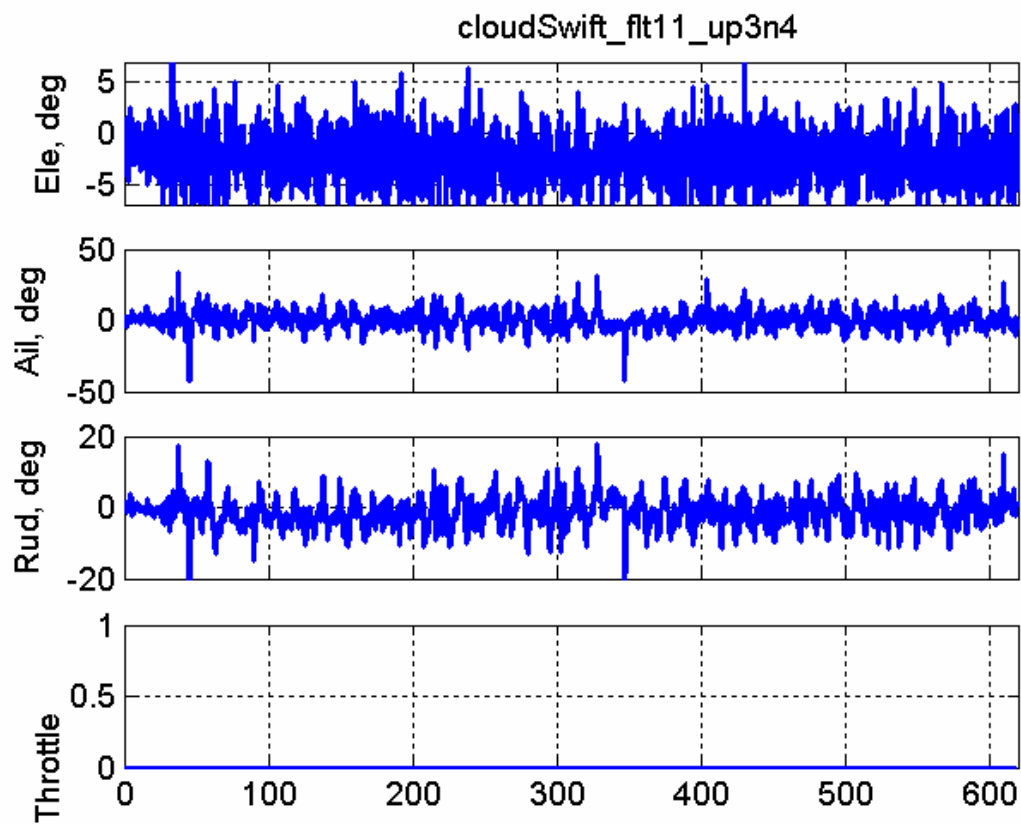
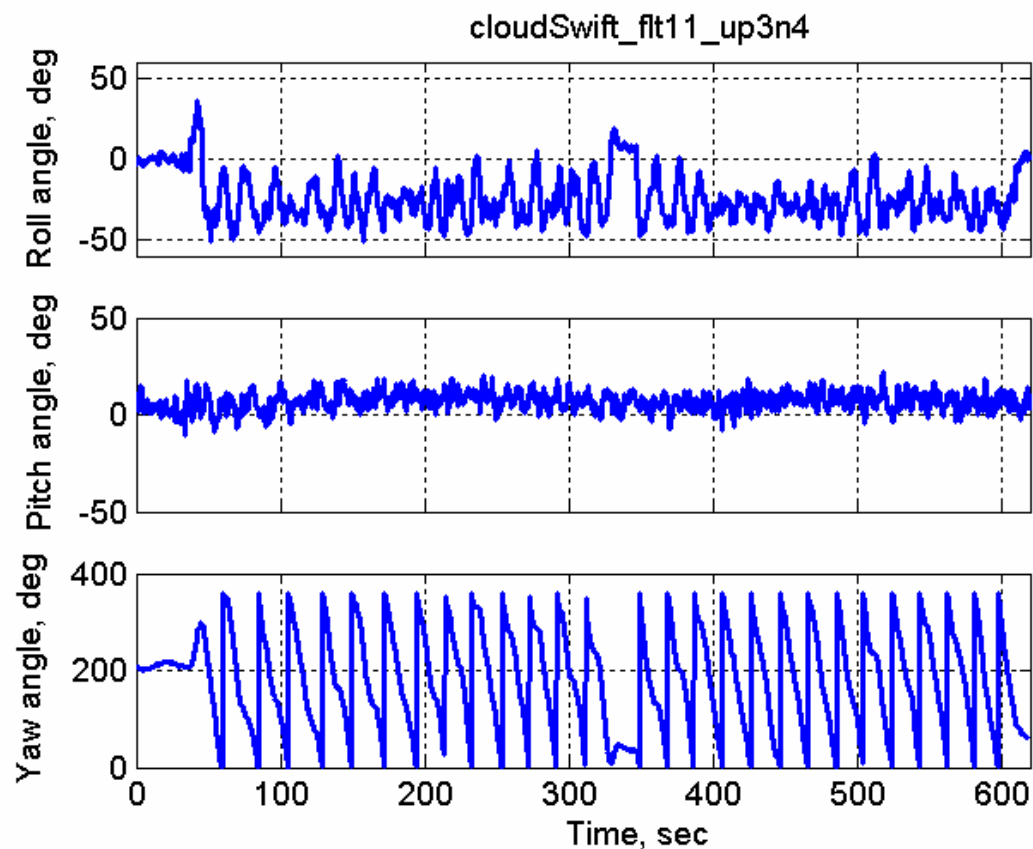
OK centering. Good match on shape.

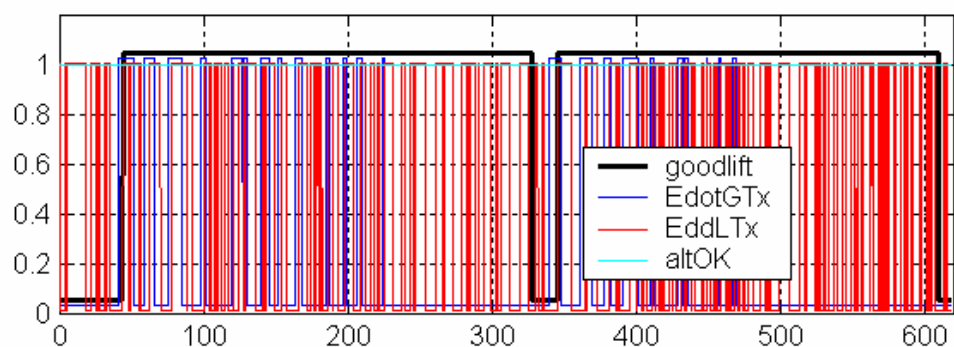




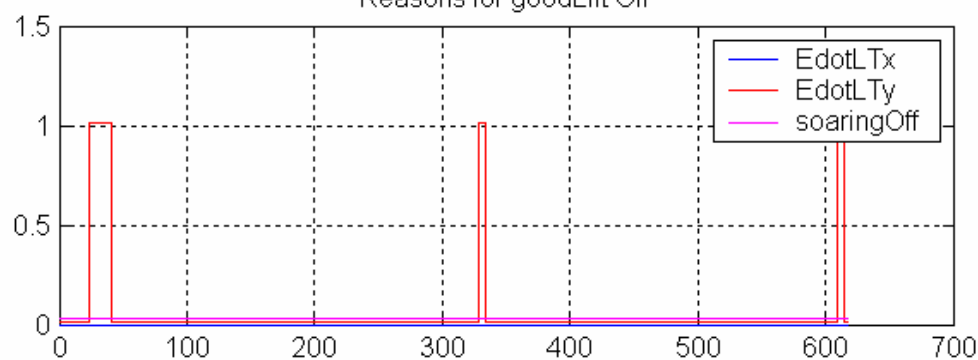
cloudSwift_ft11_up3n4



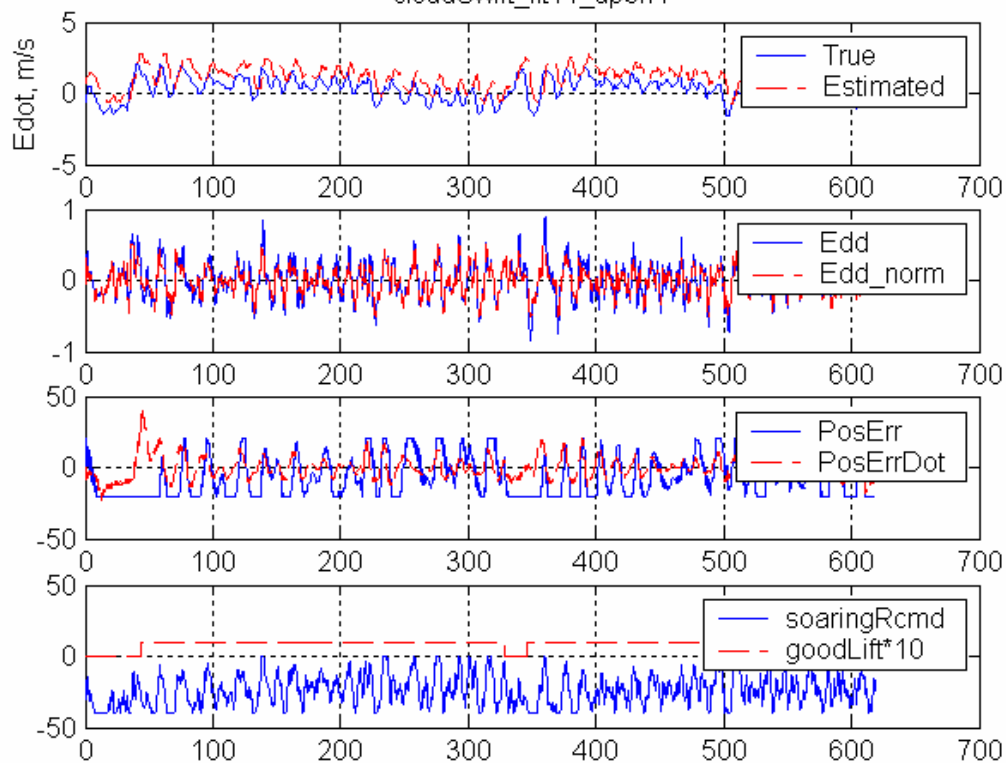




Reasons for goodLift Off

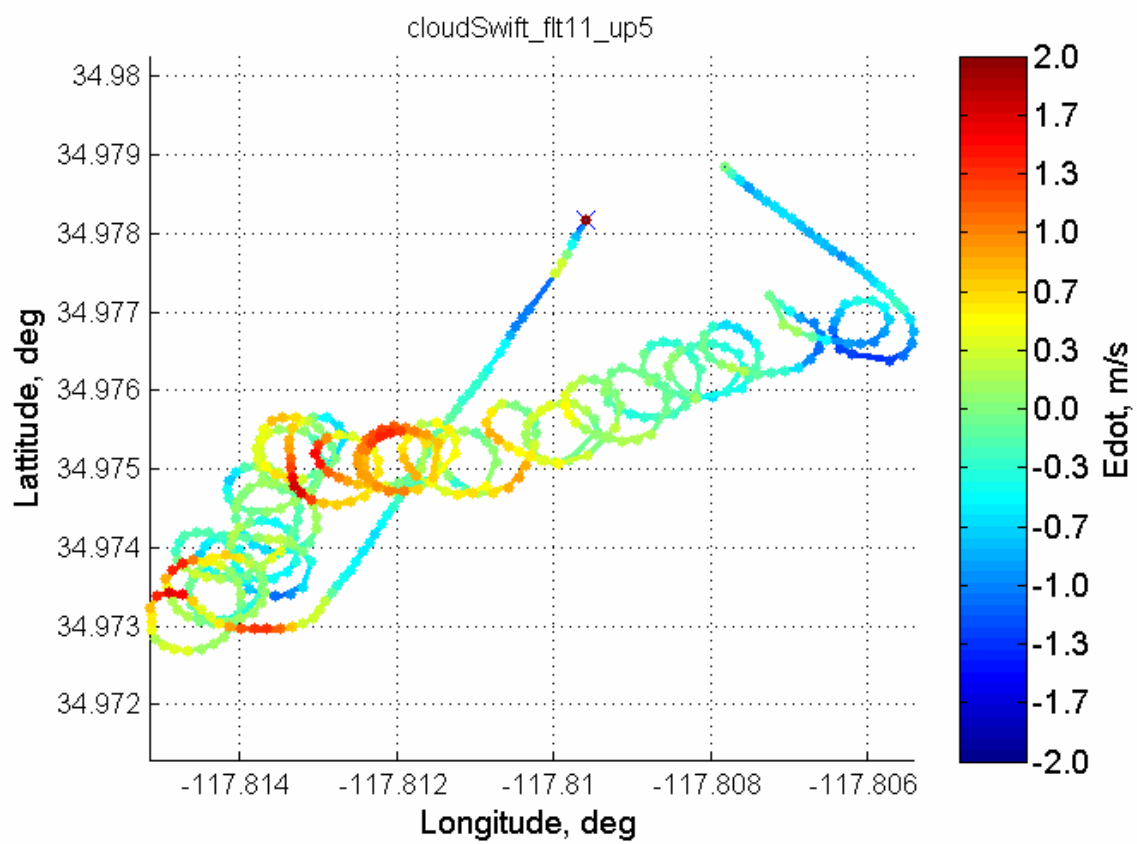


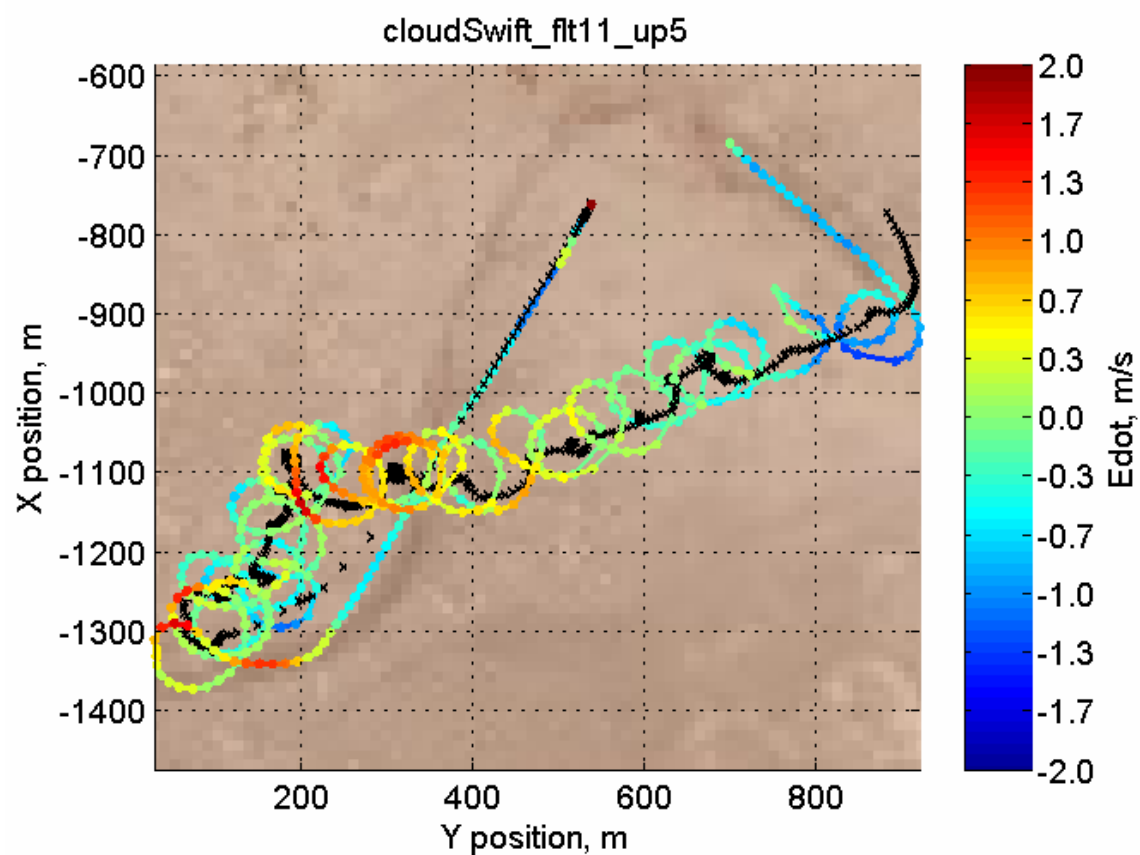
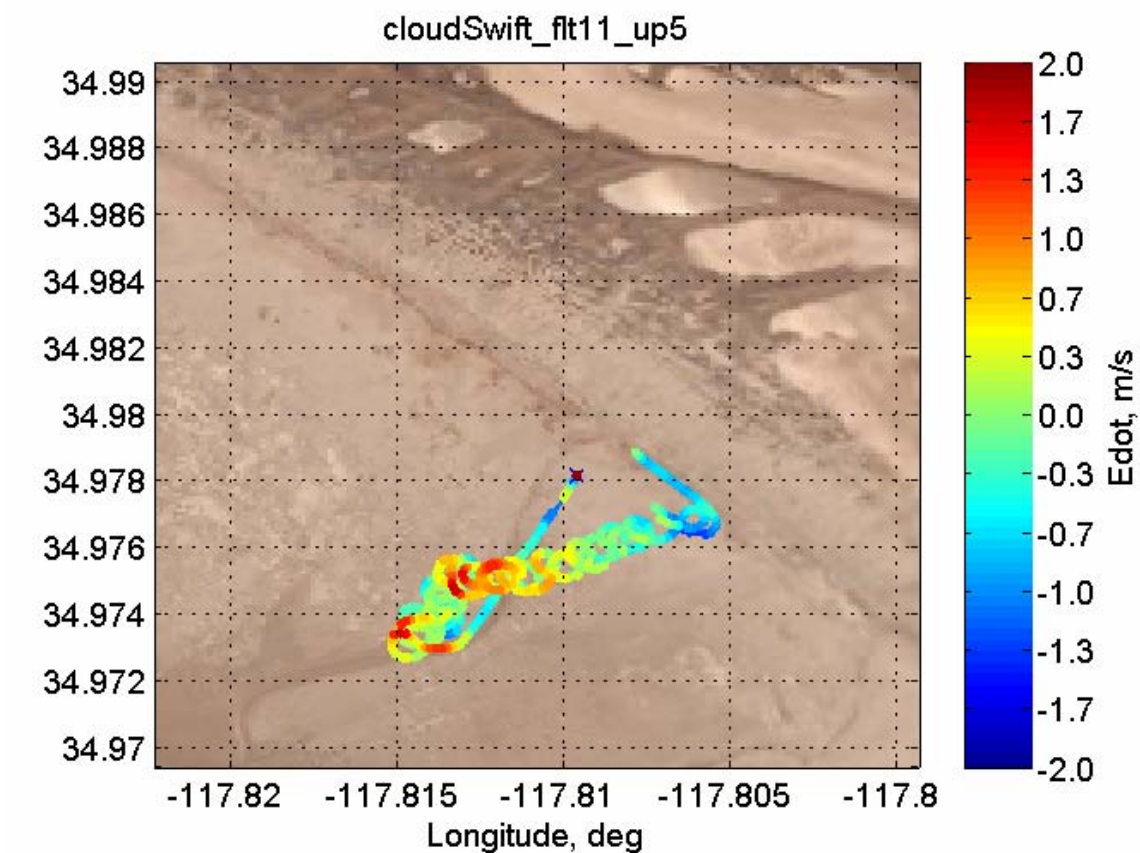
cloudSwift_fit11_up3n4

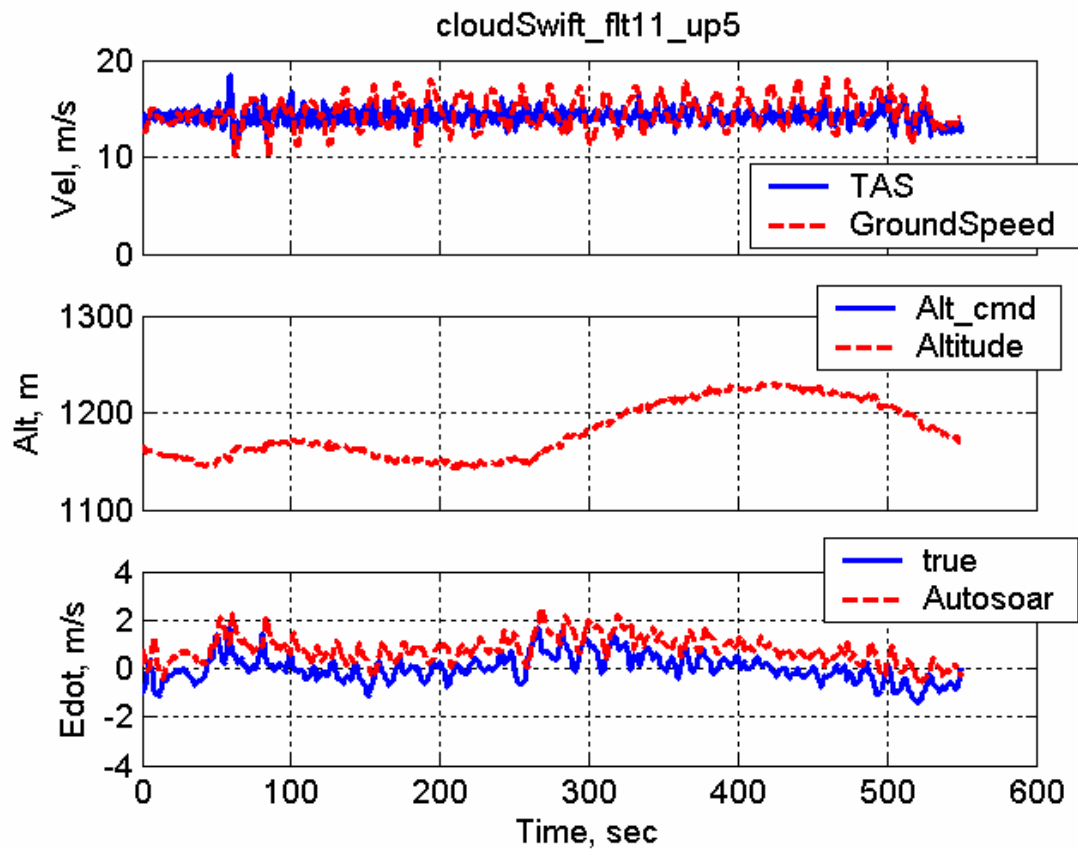
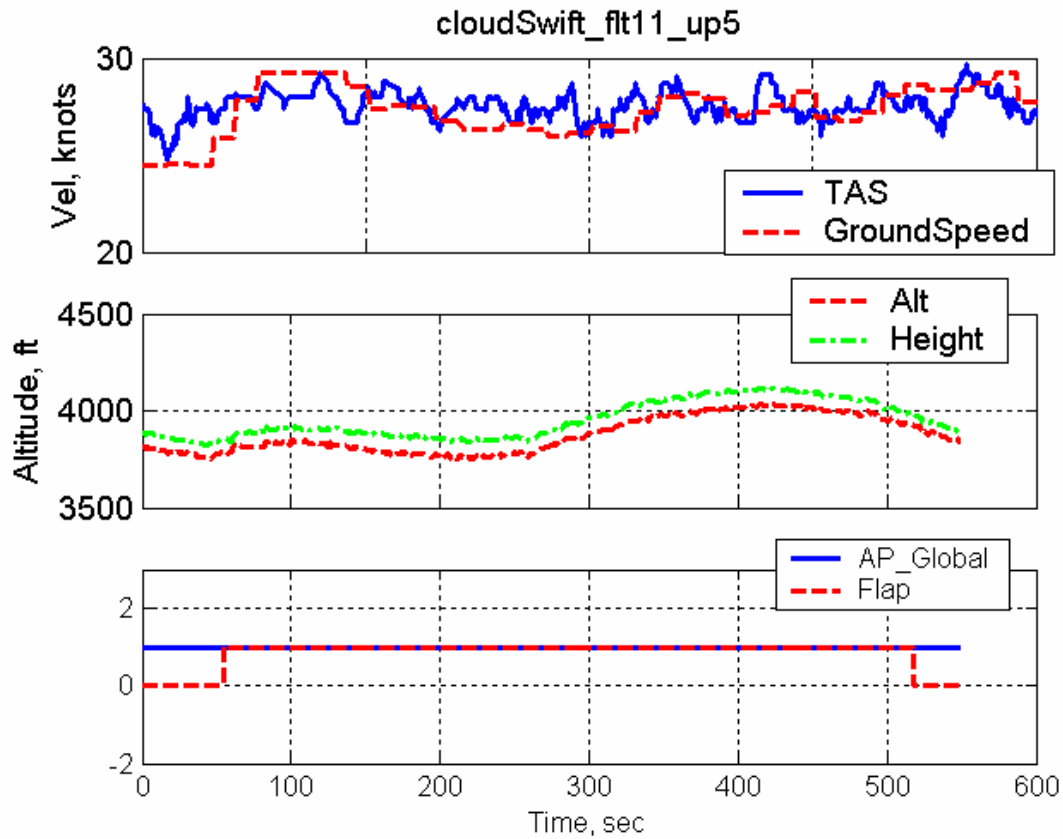


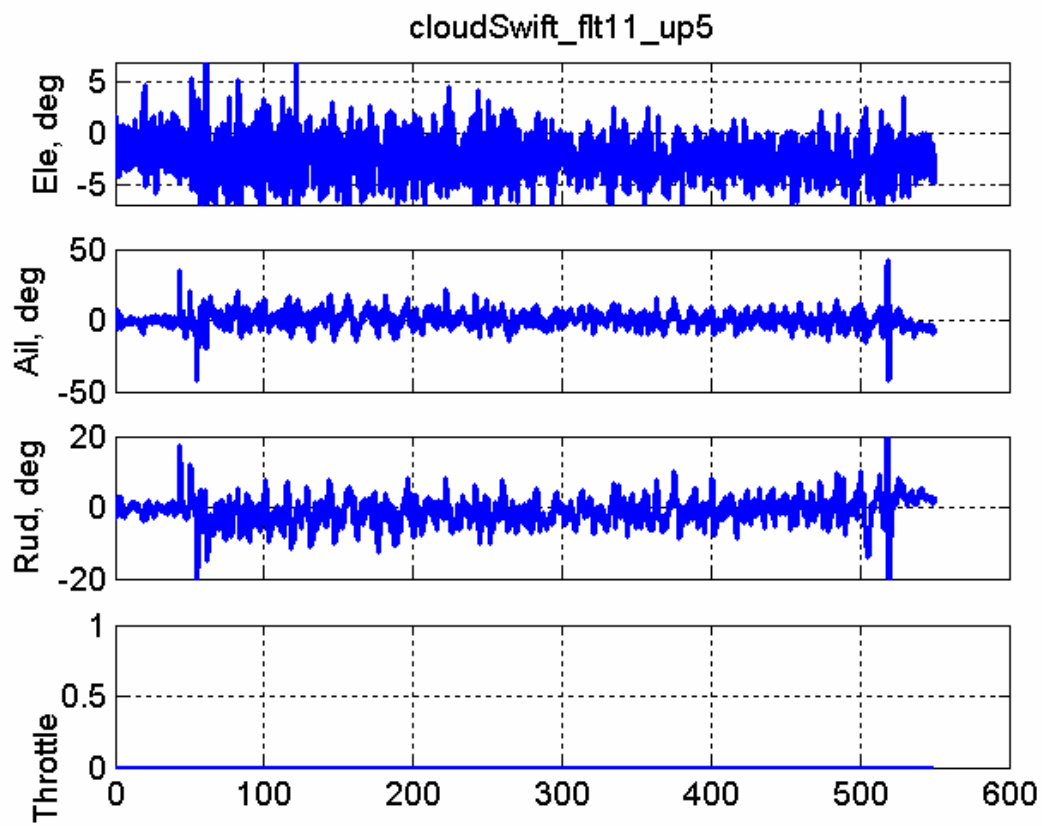
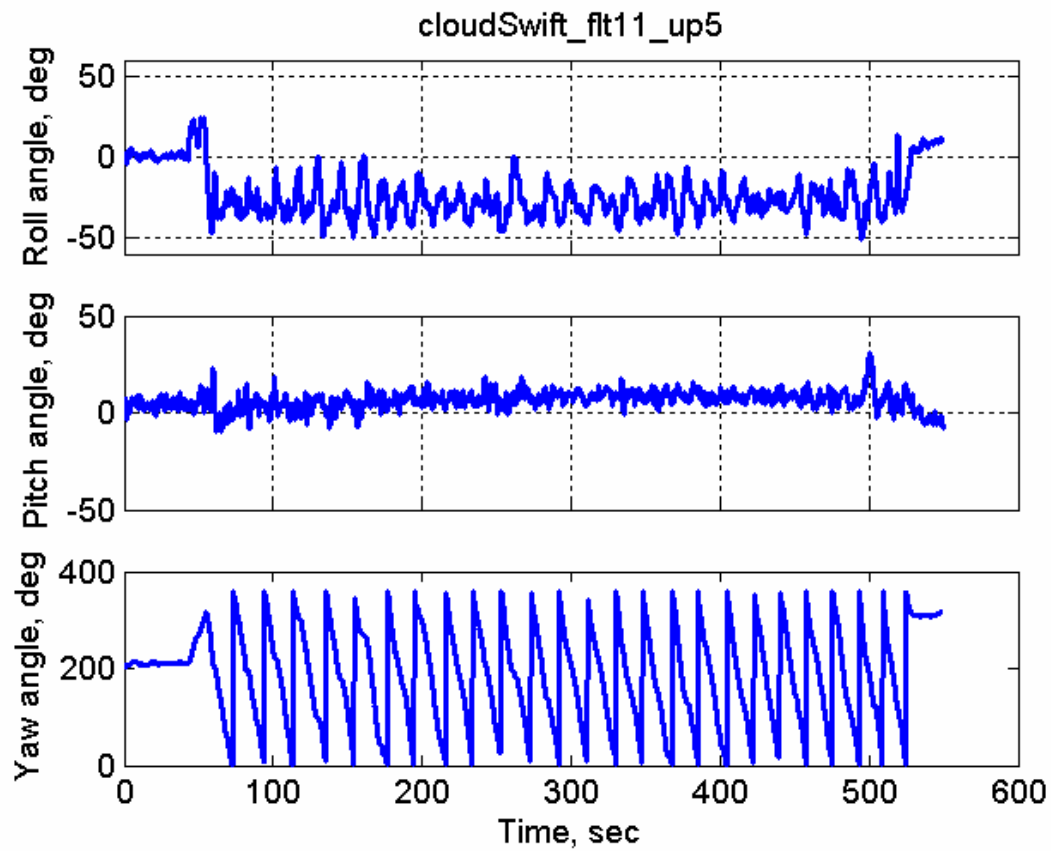
Flight 11, updraft 5

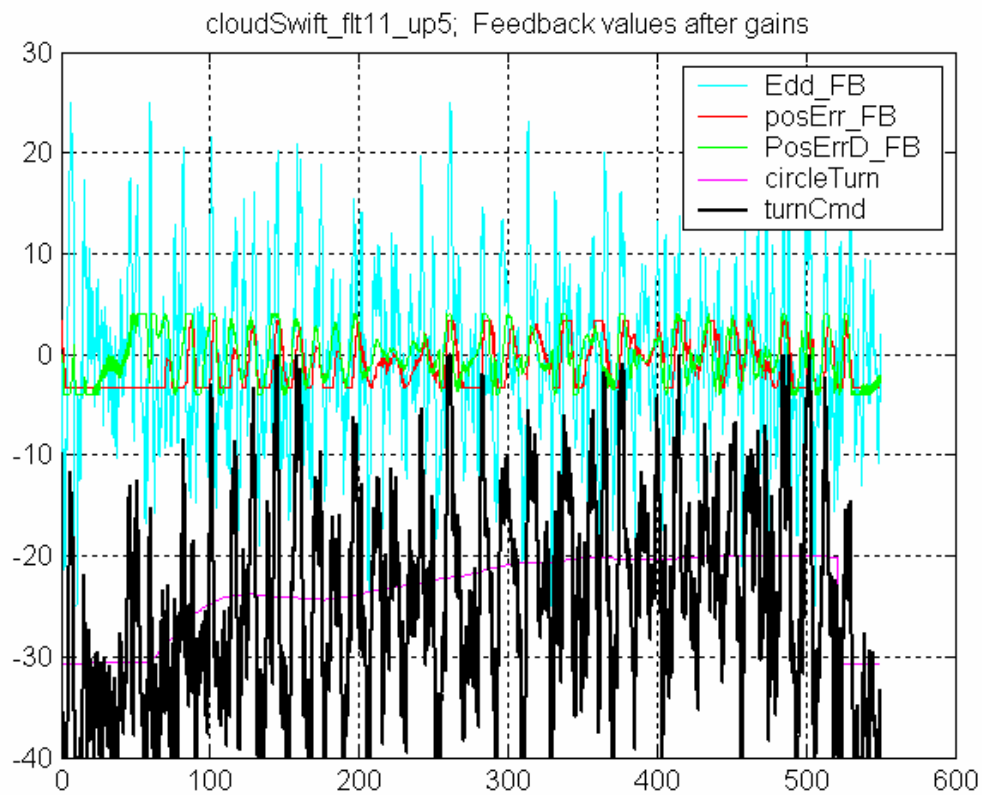
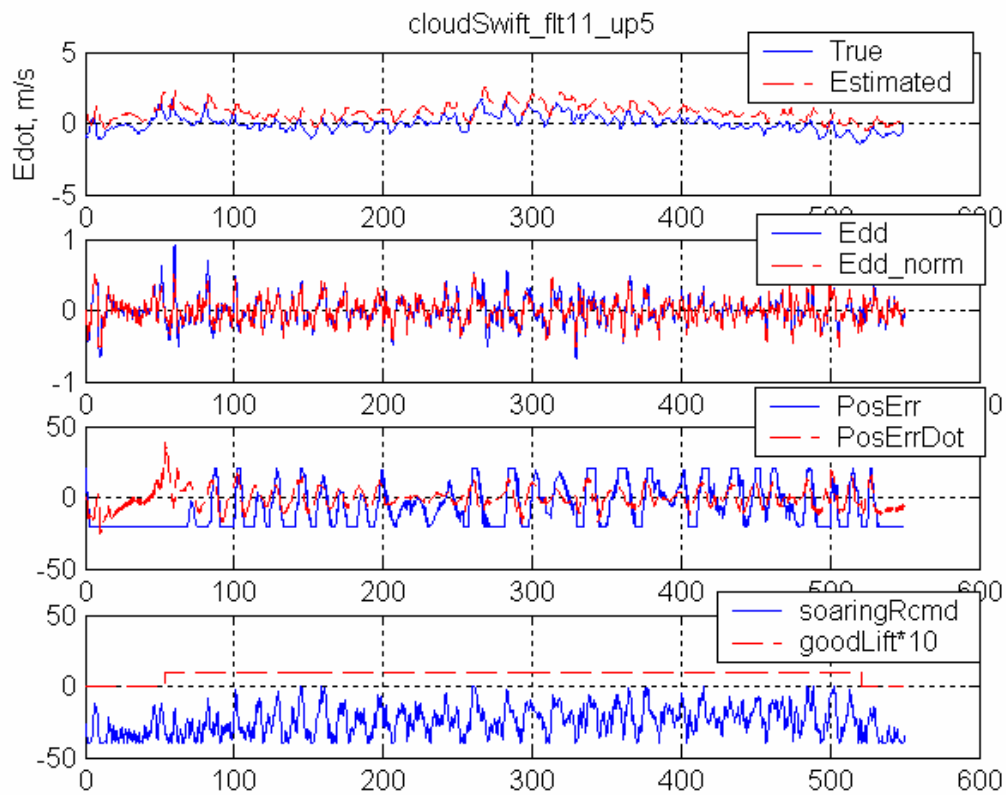
Shifting lift. Good for study. Drift calc may have reduced performance.





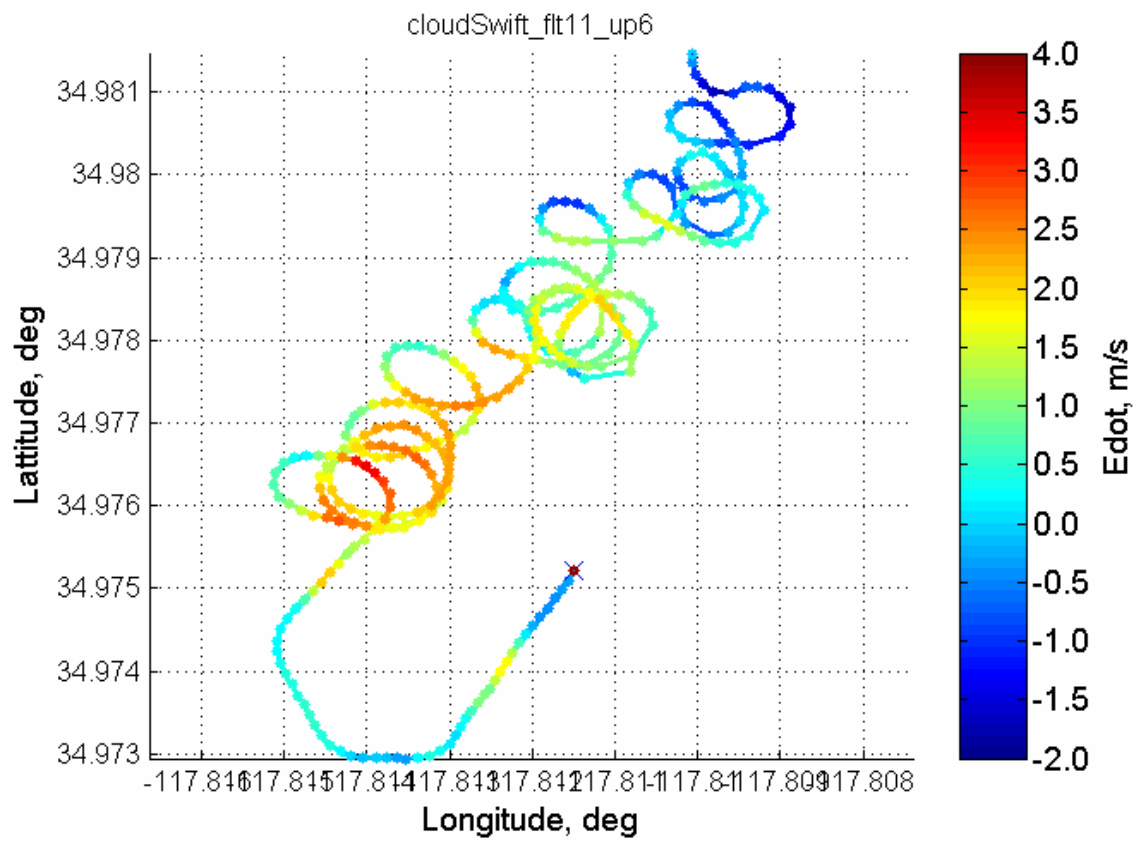


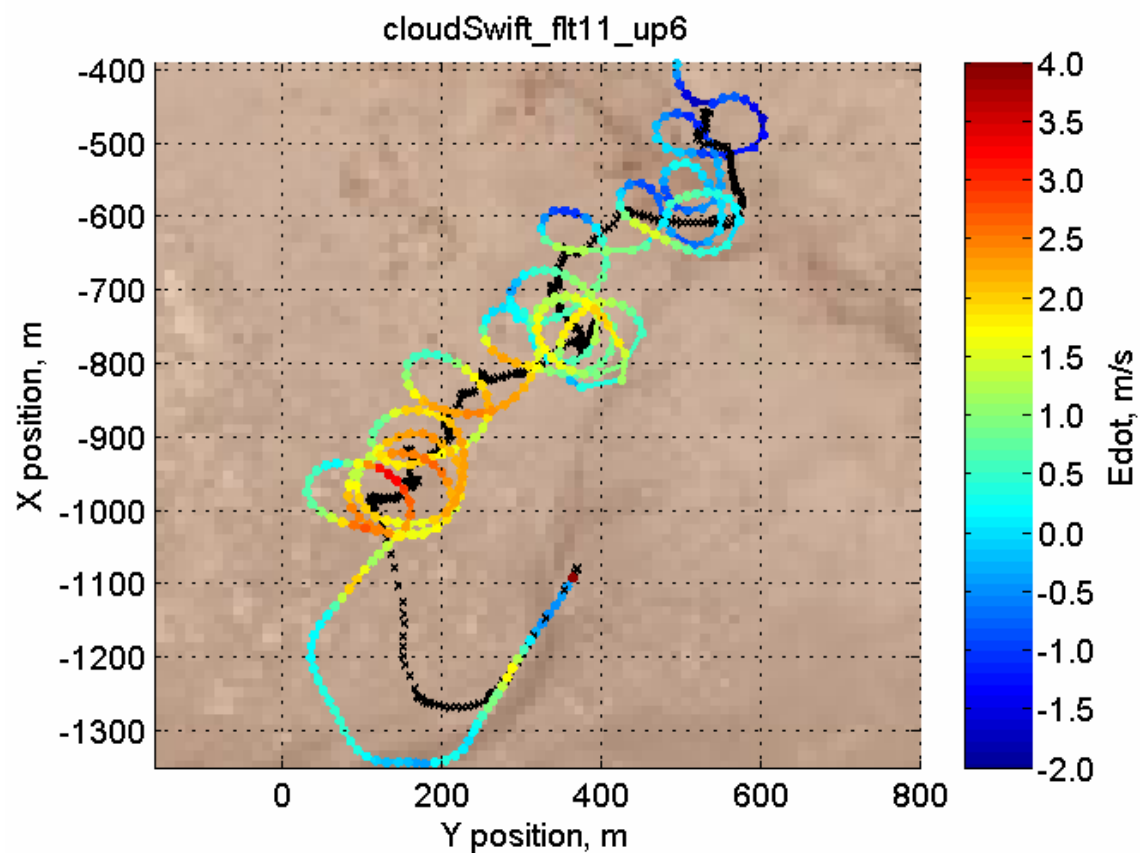
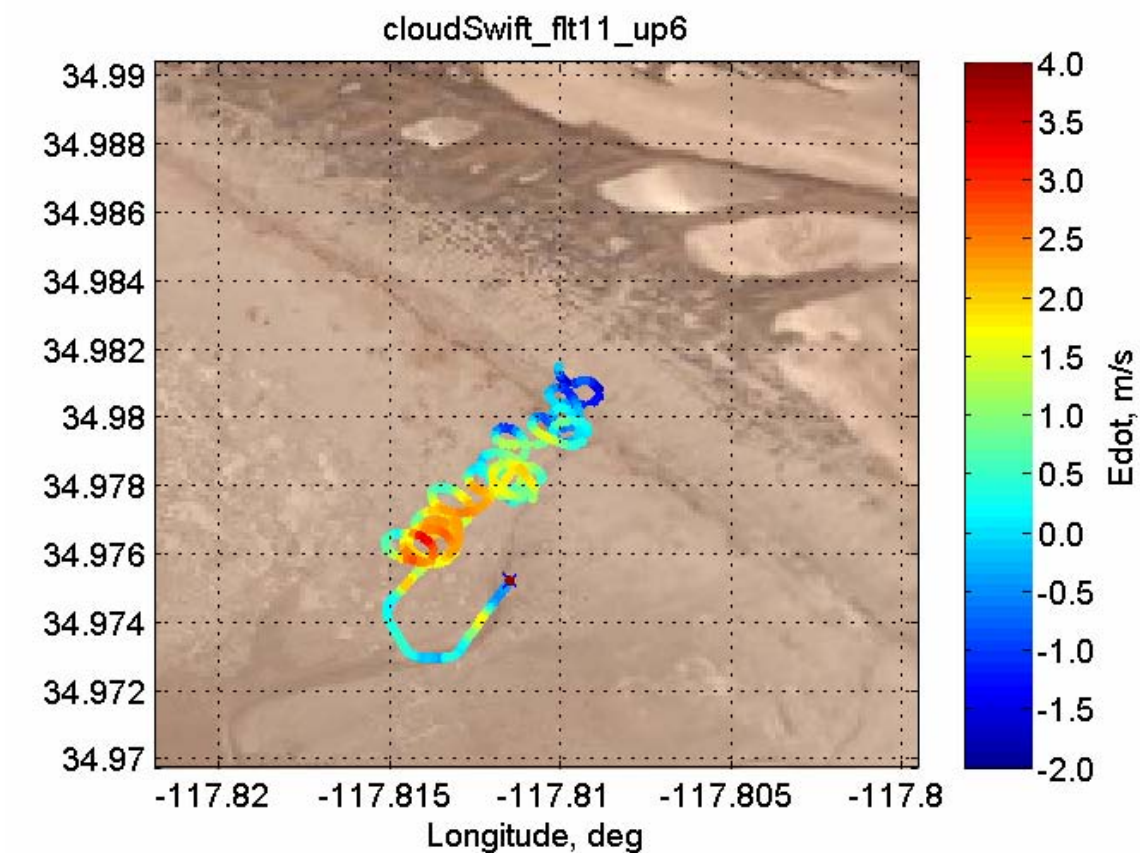


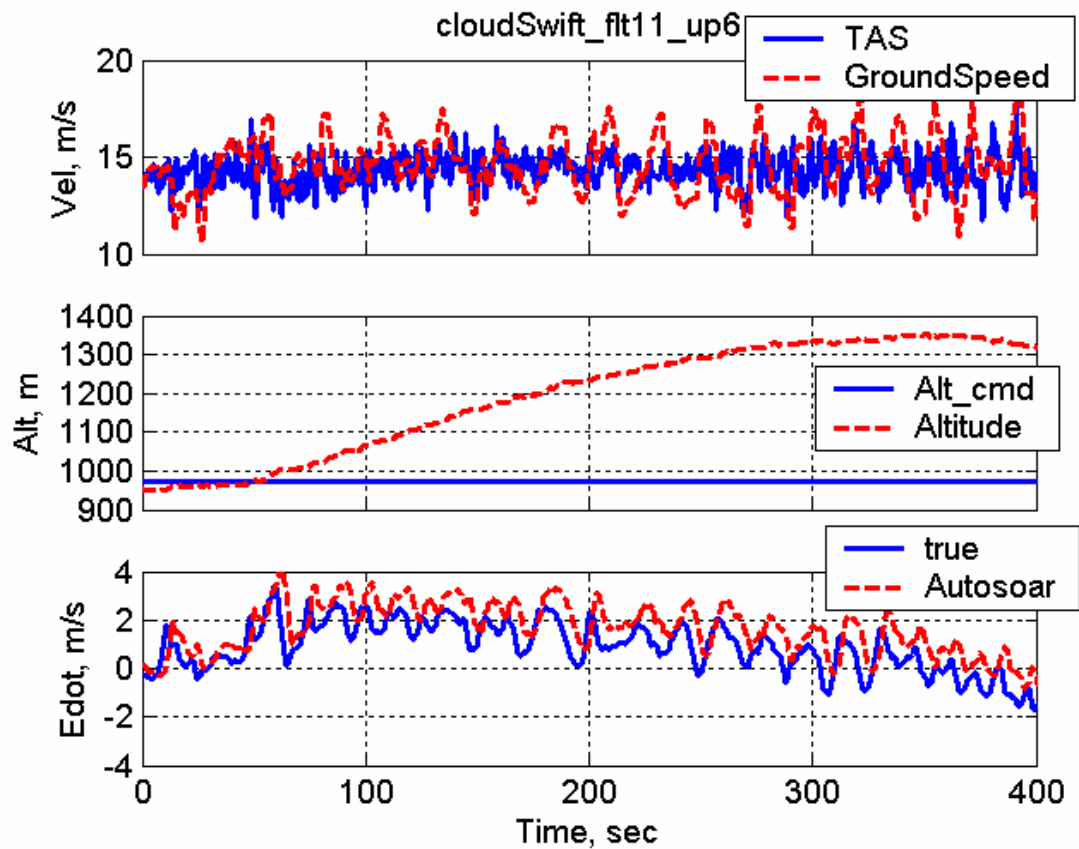
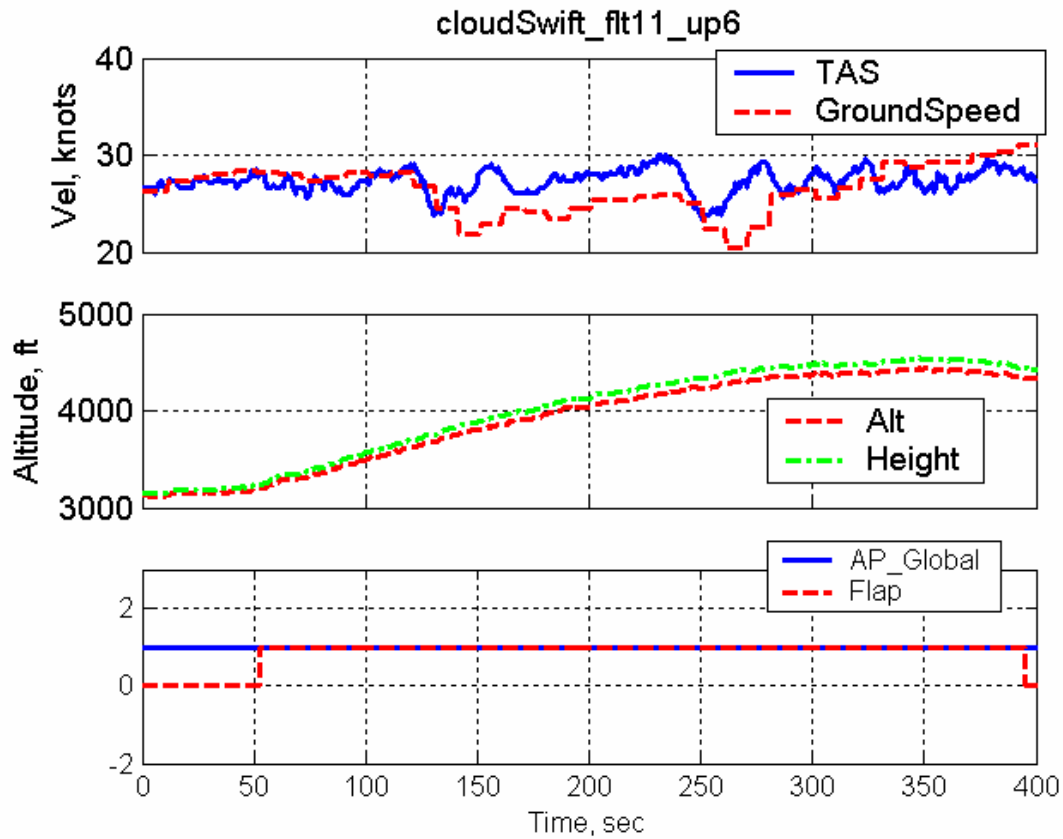


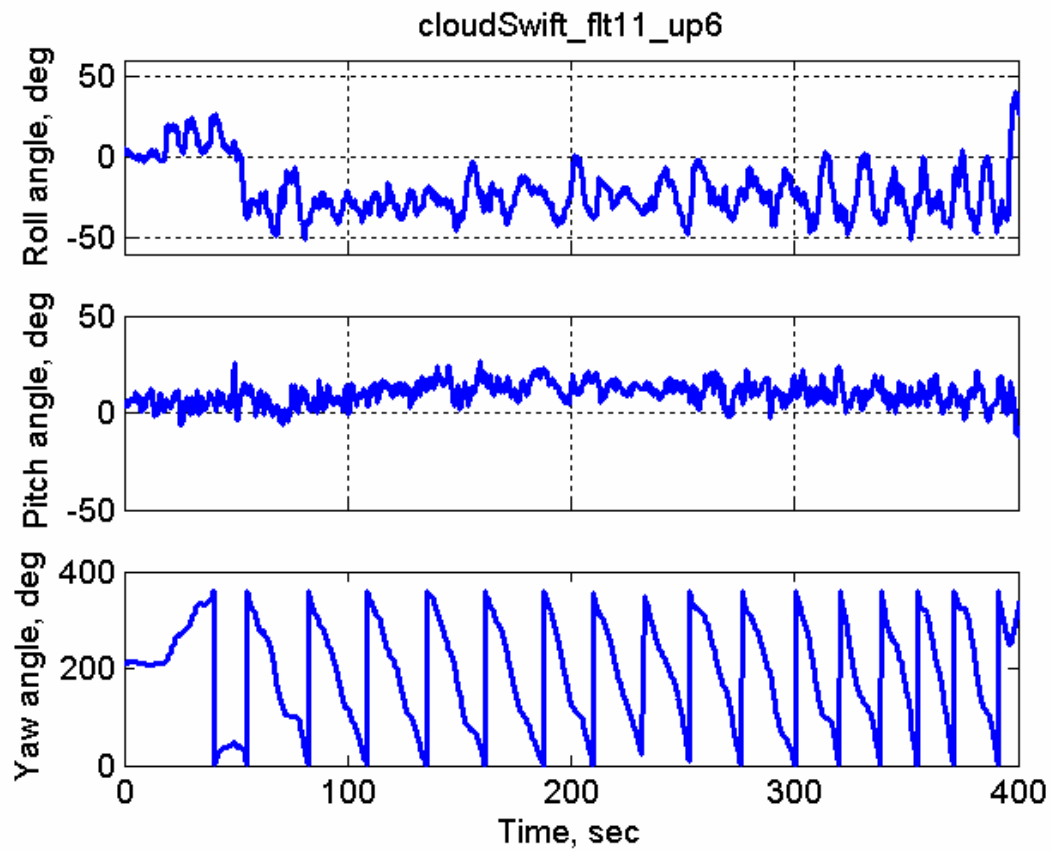
Flight 11, updraft 6

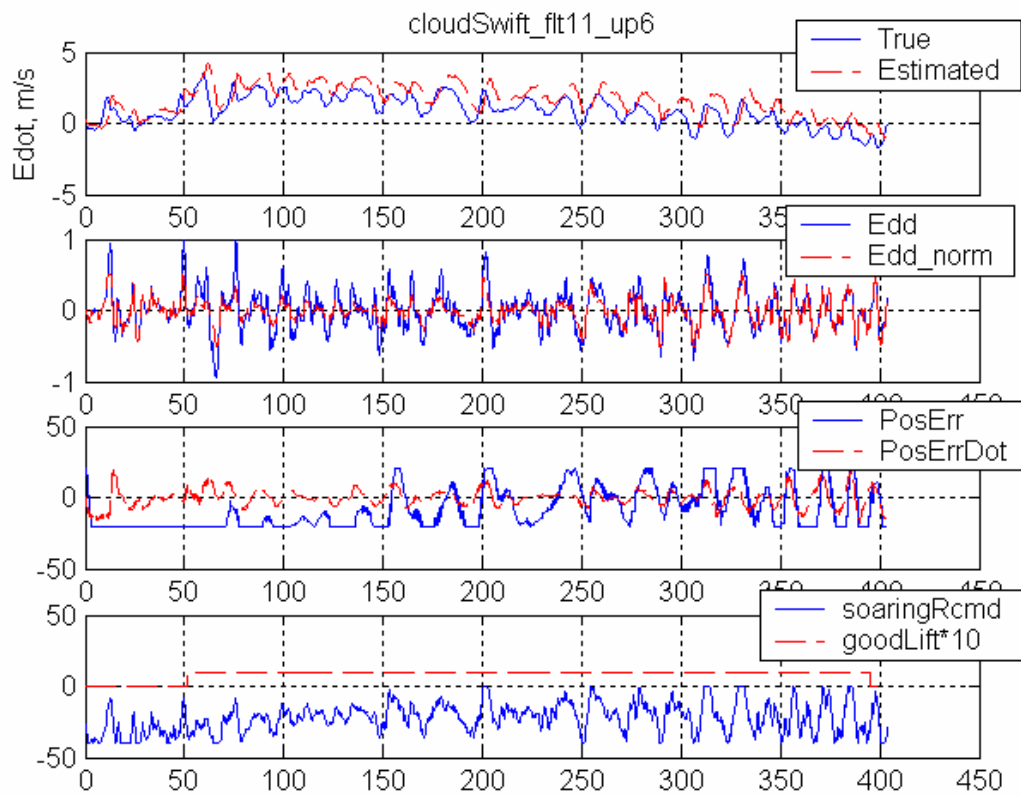
Good centering but strong Edd feedback sends it away from lift toward end.





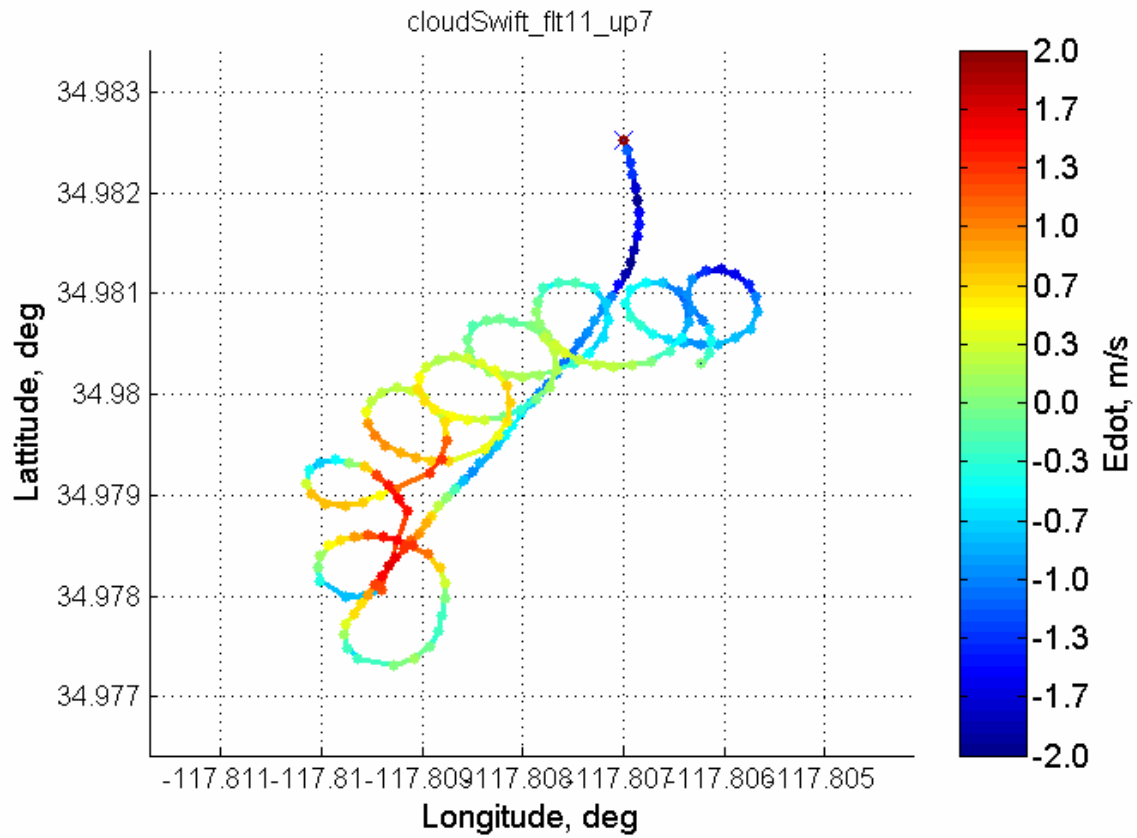


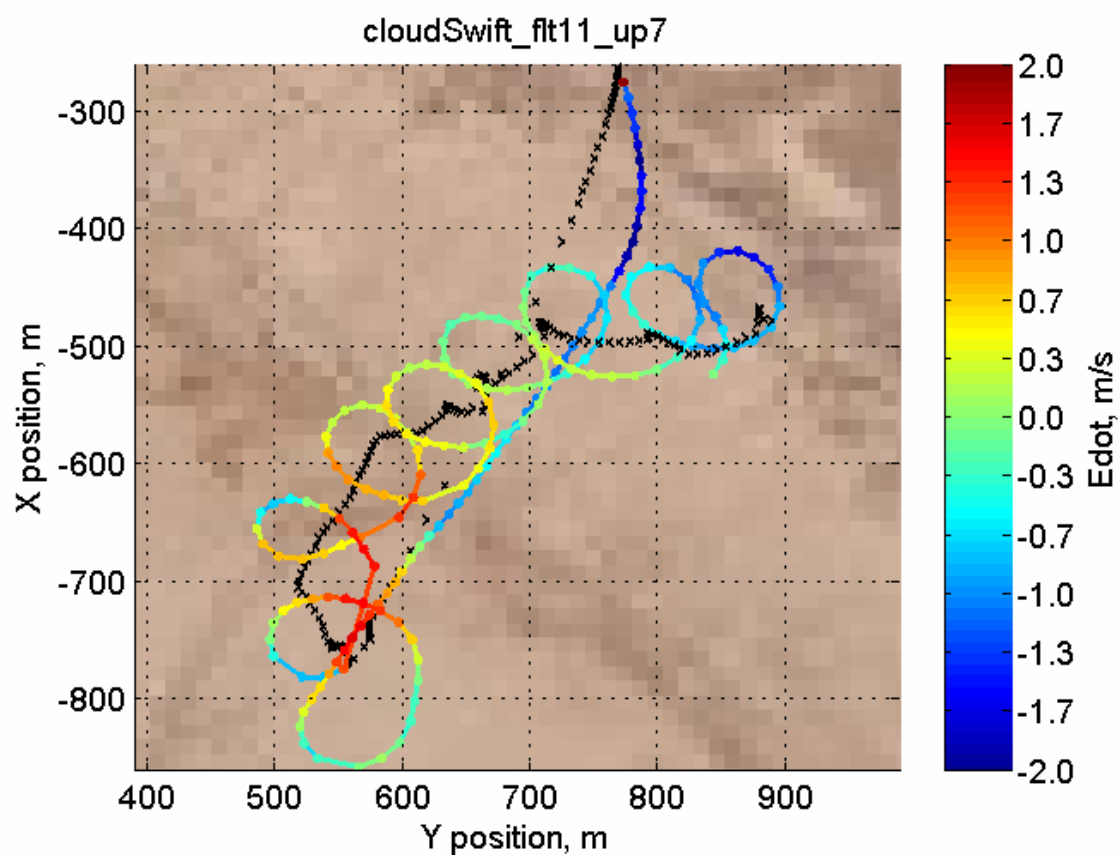
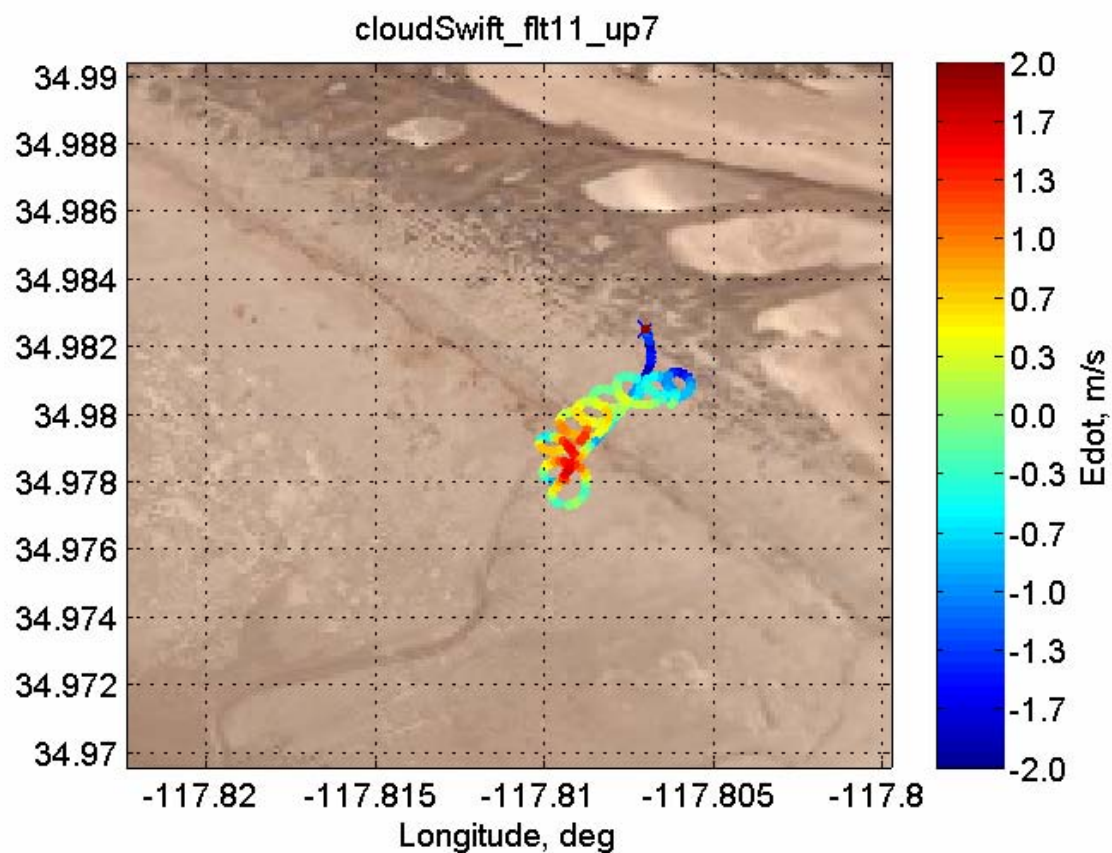


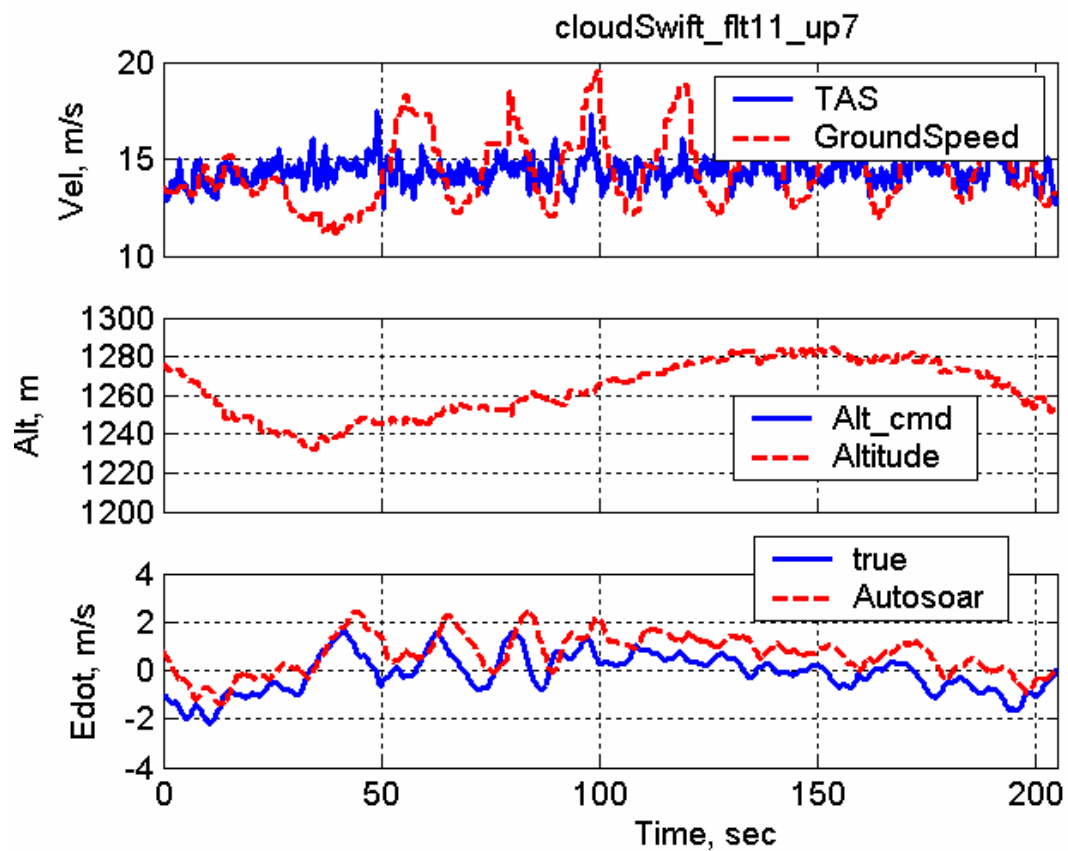
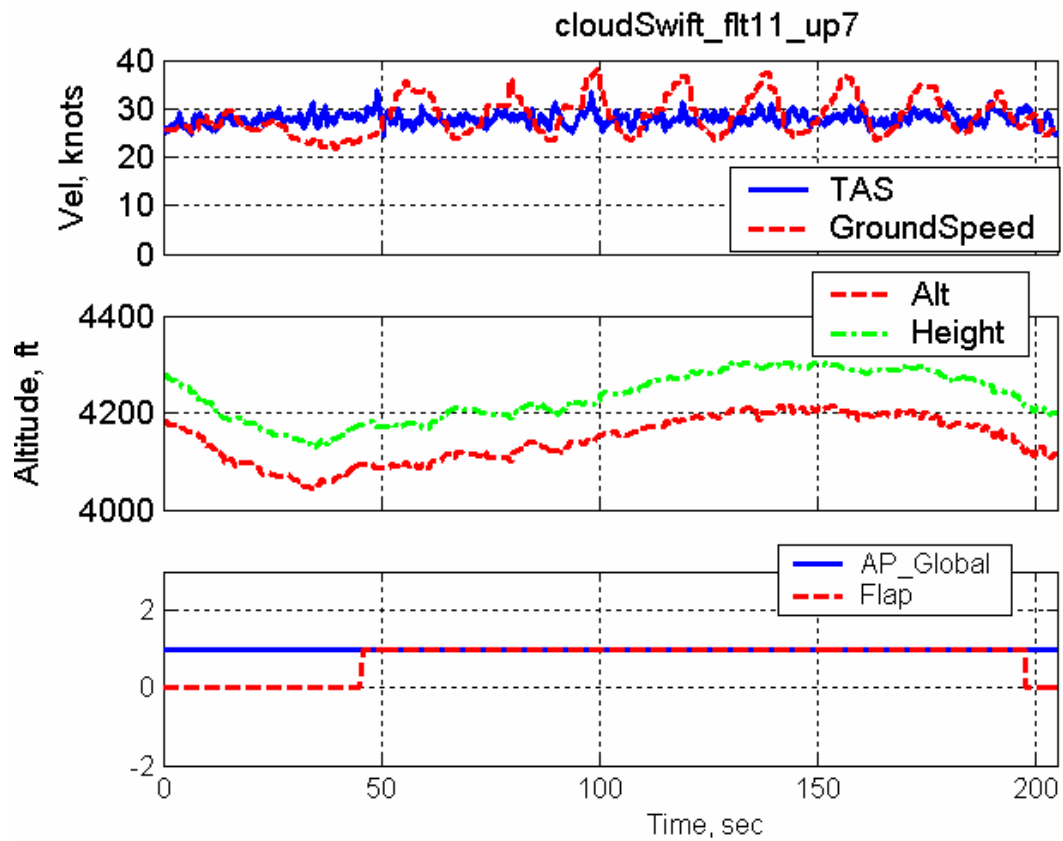


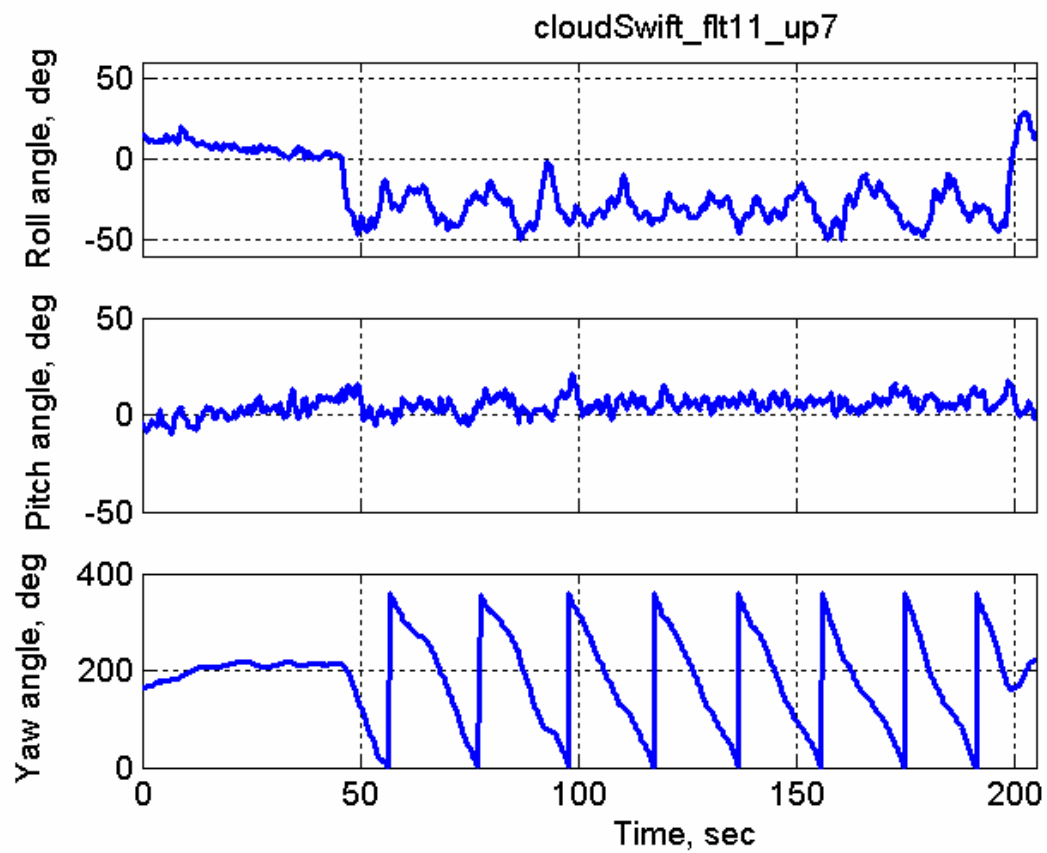
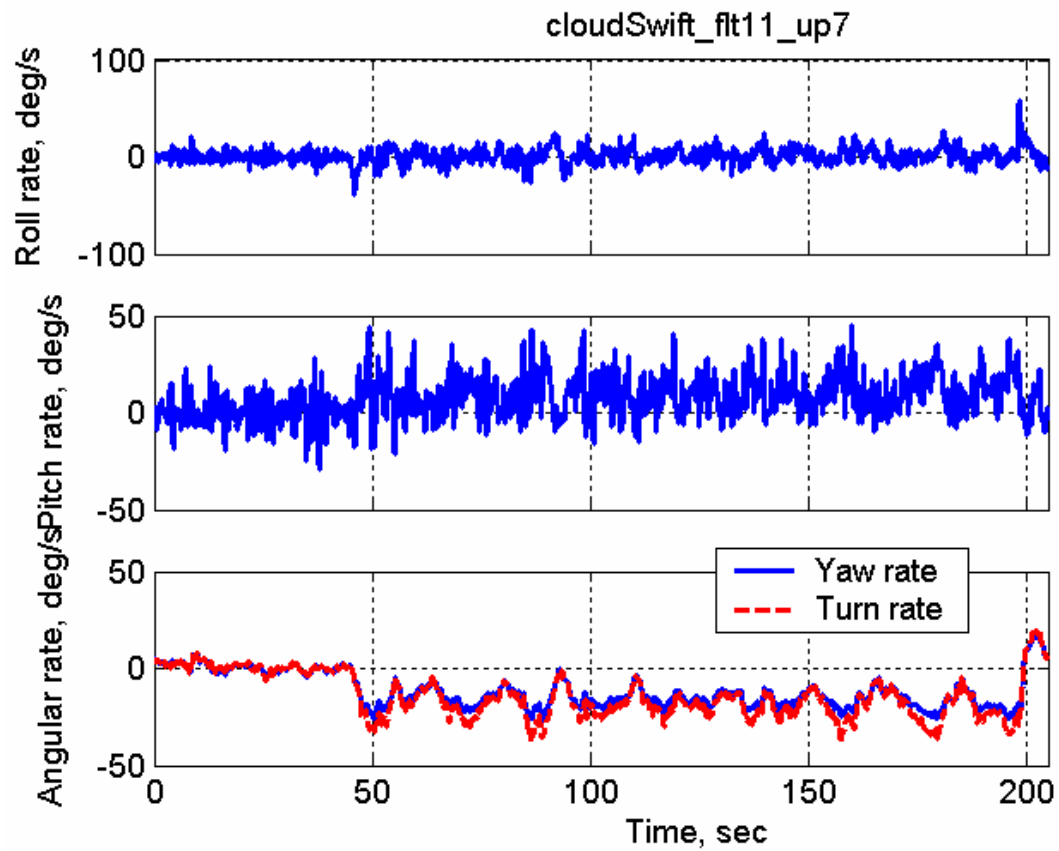
Flight 11, updraft 7

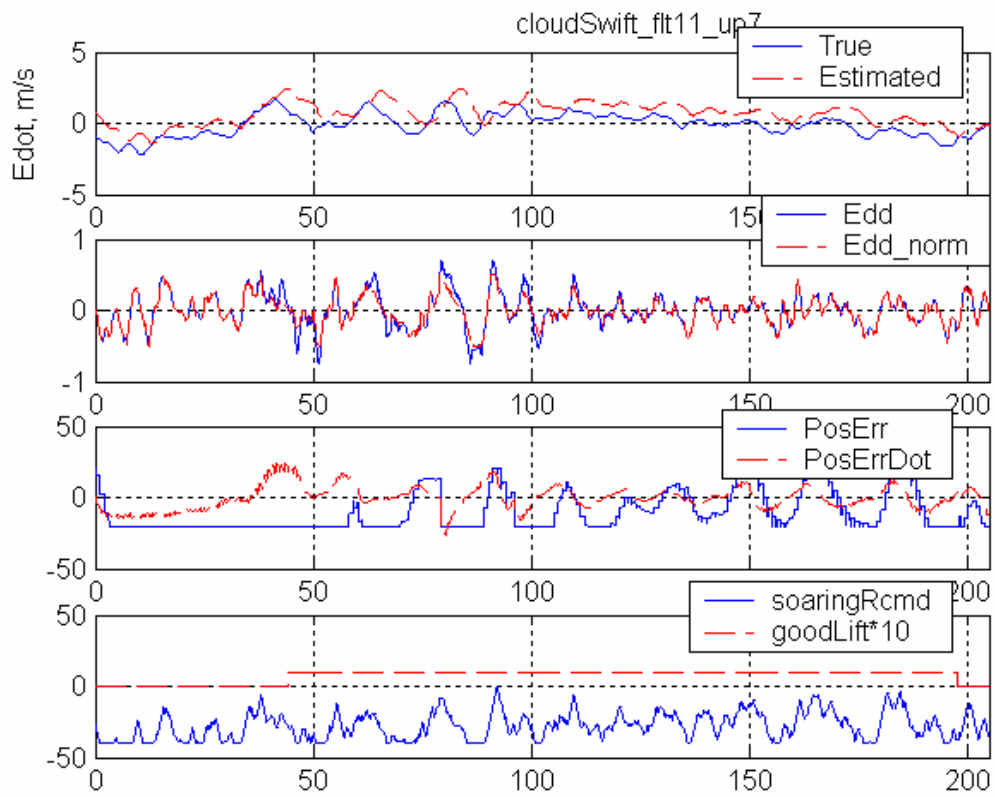
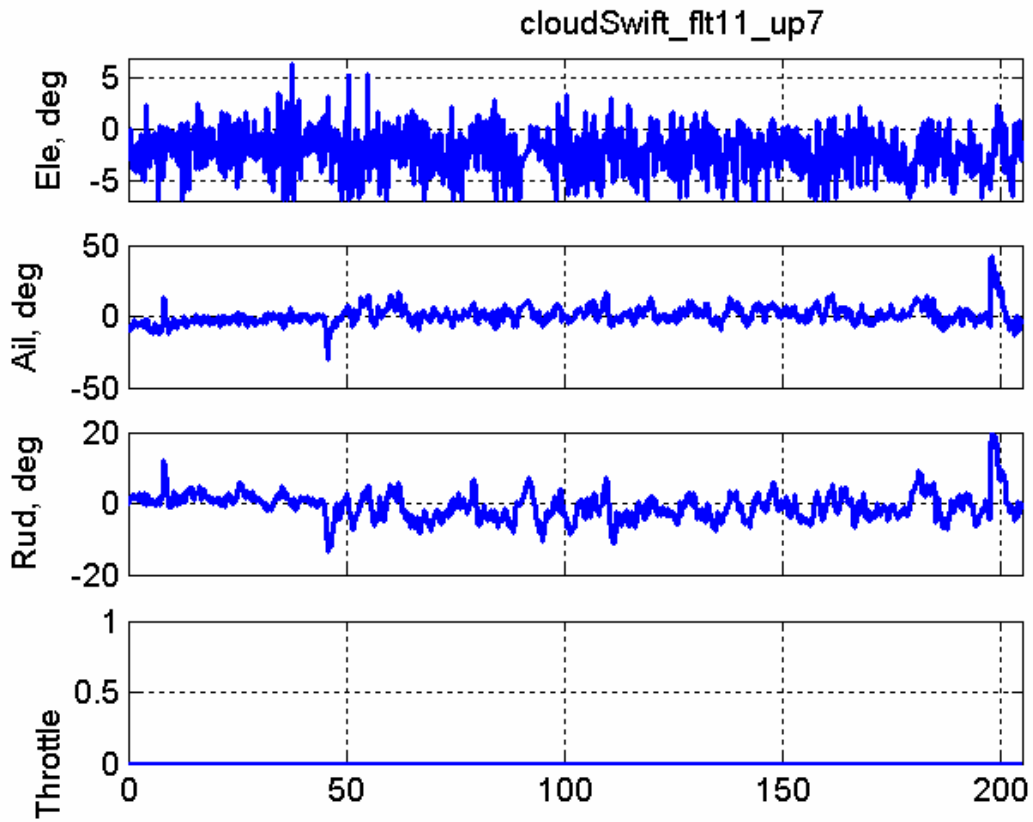
Nice little example of OK centering in 2m/s lift. Never quite centers it.

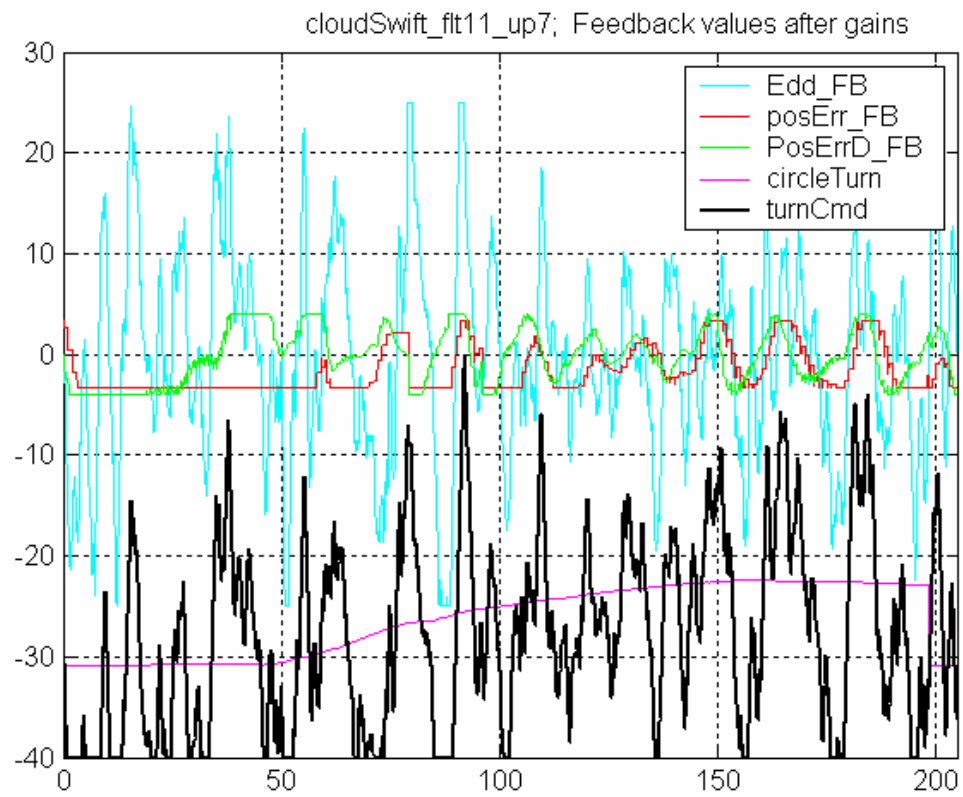






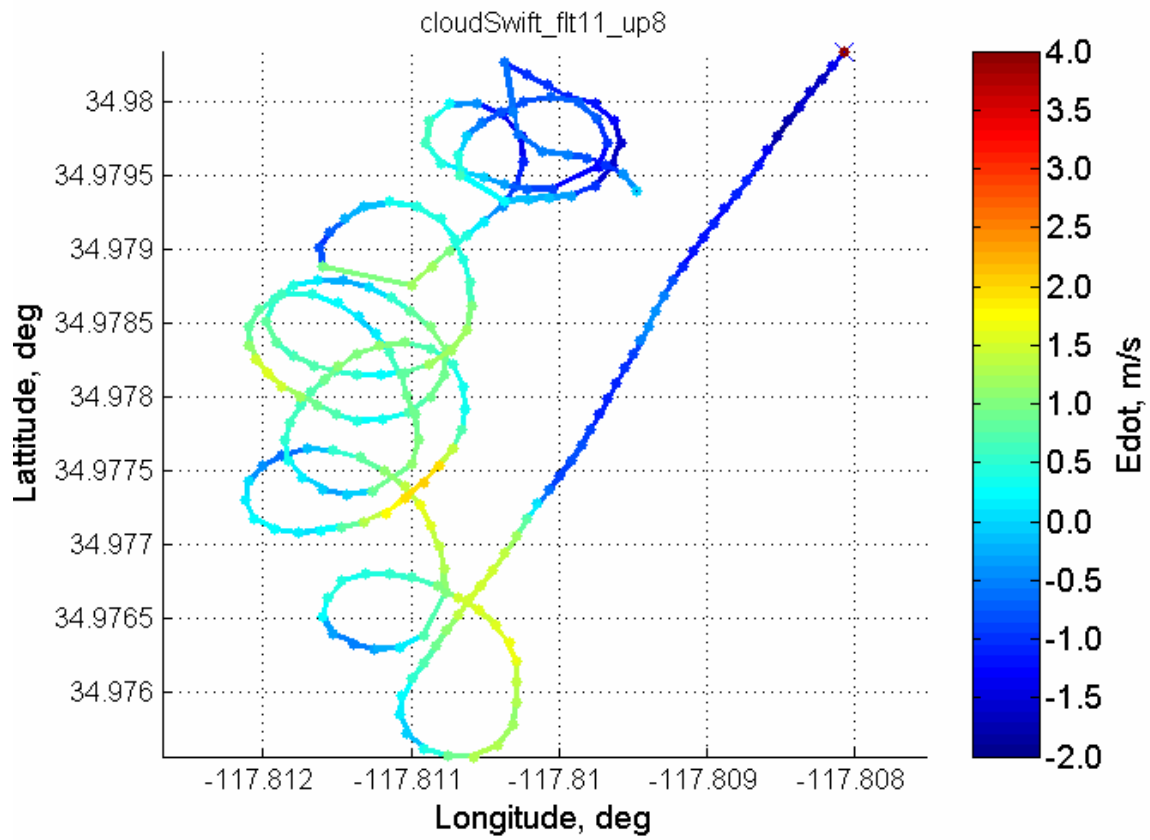


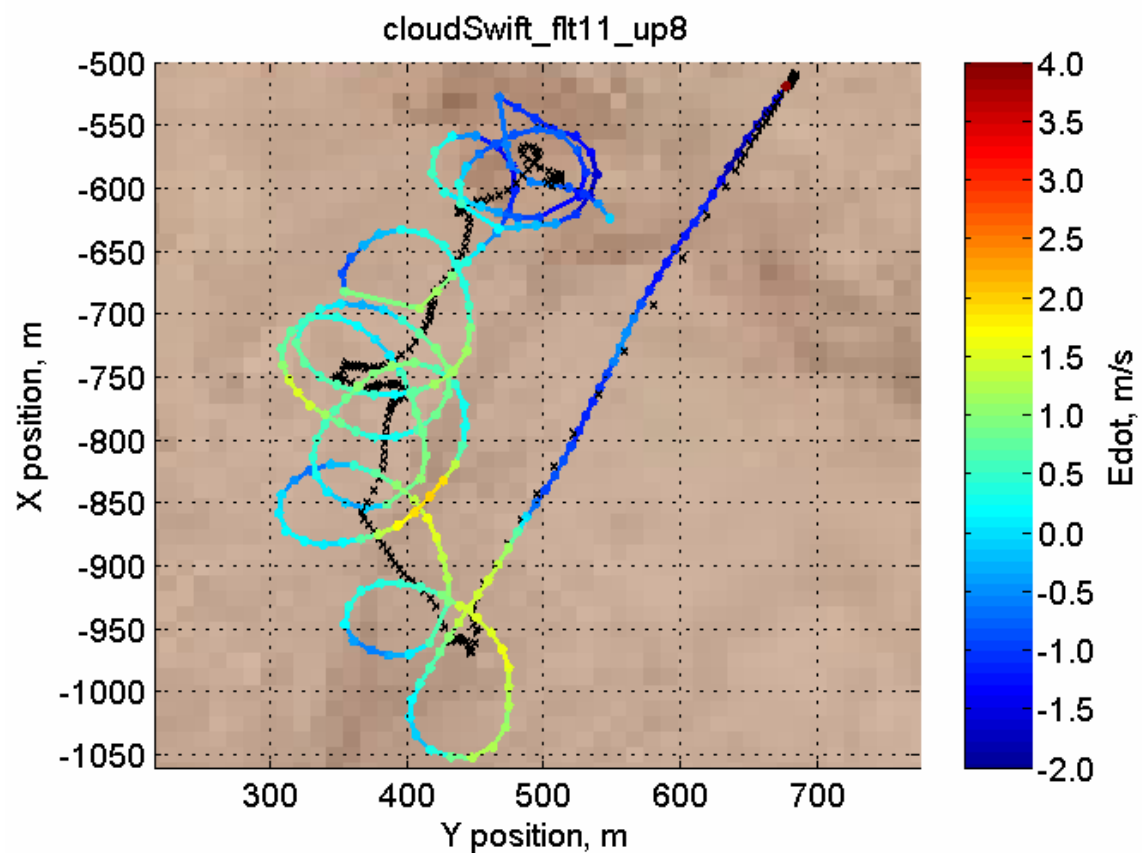
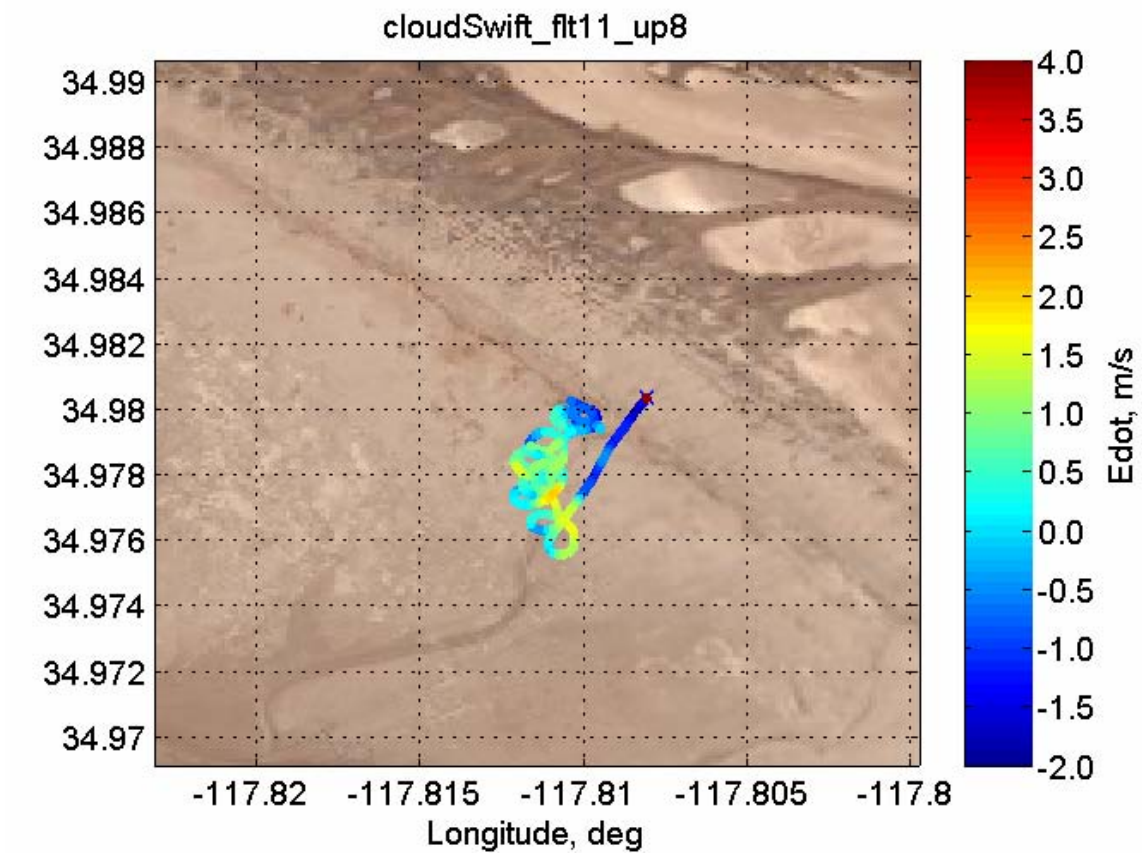


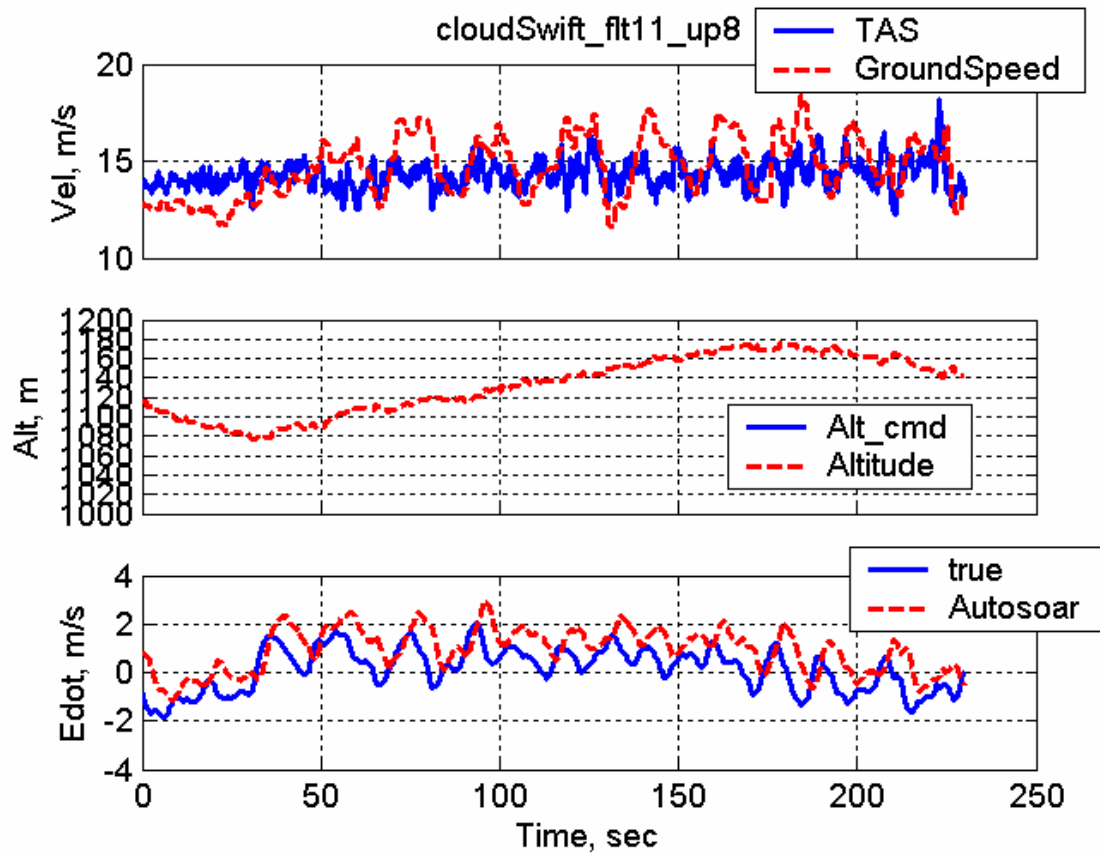
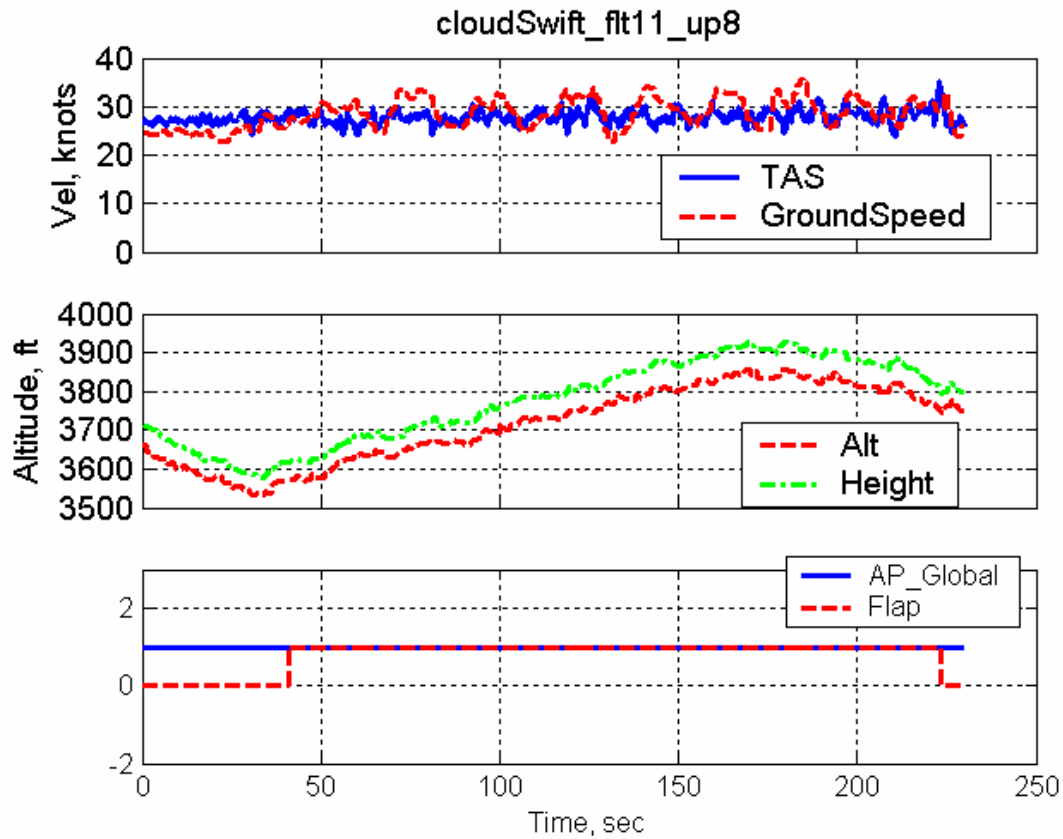


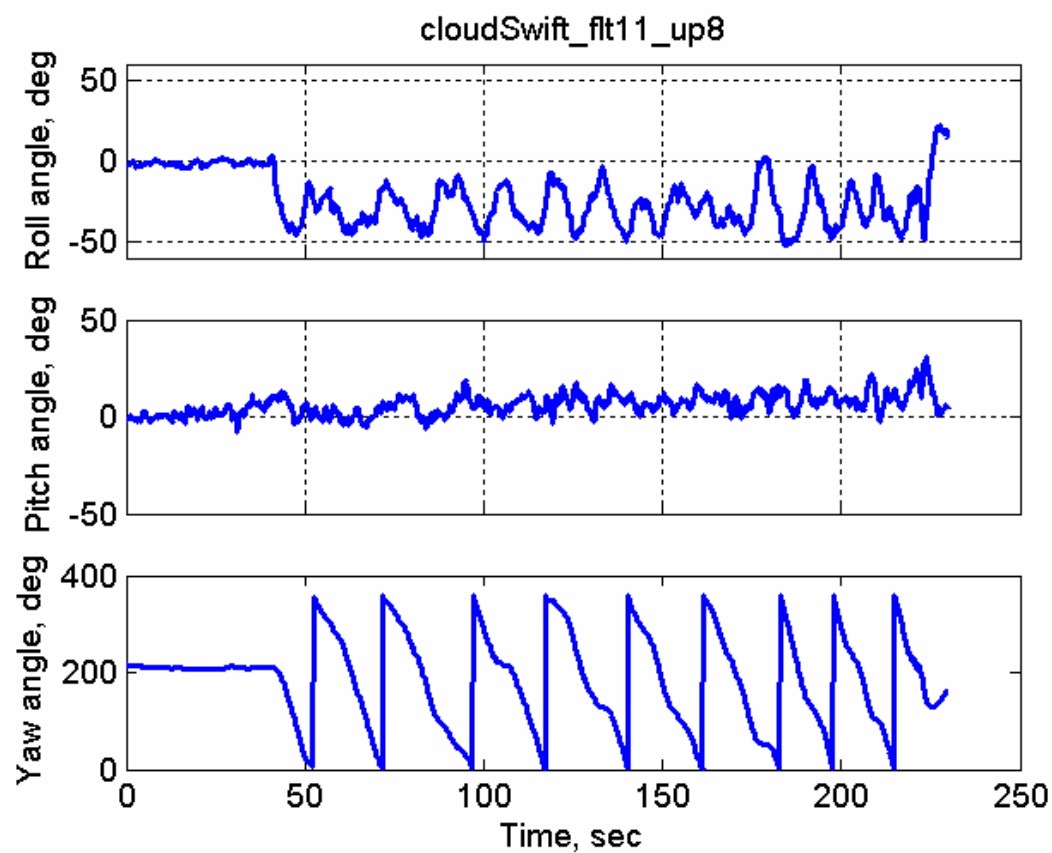
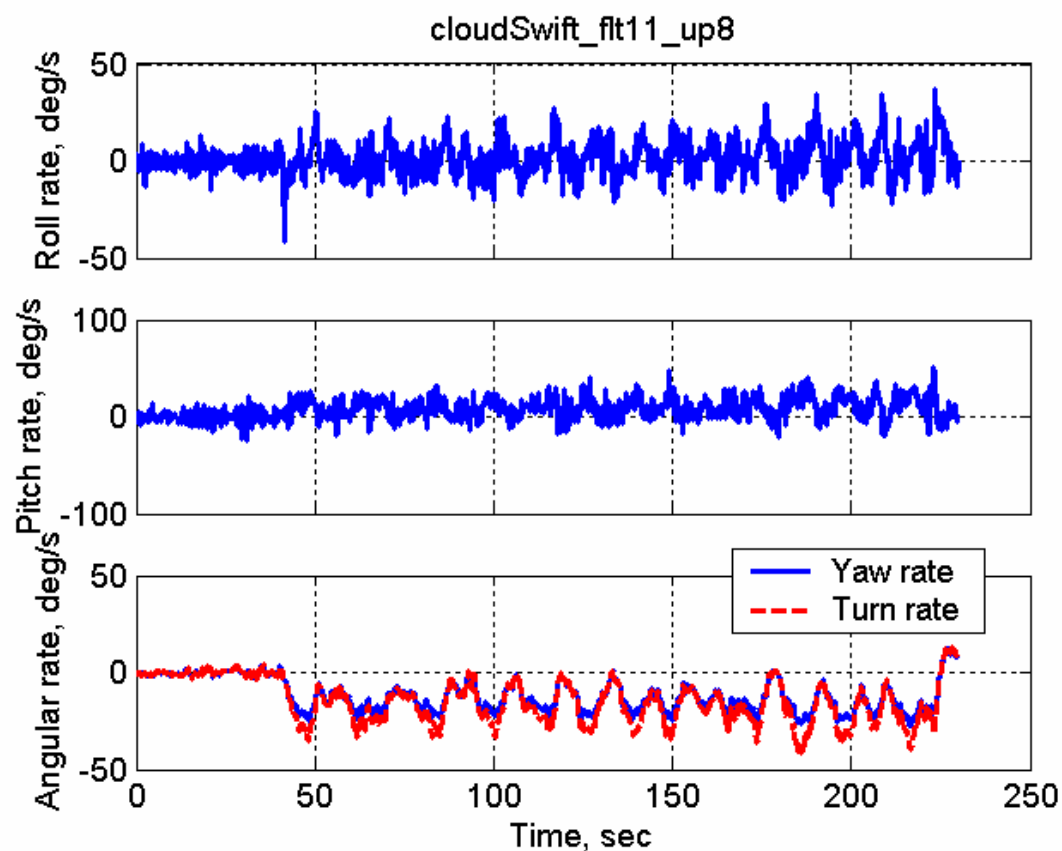
Flight 11, updraft 8

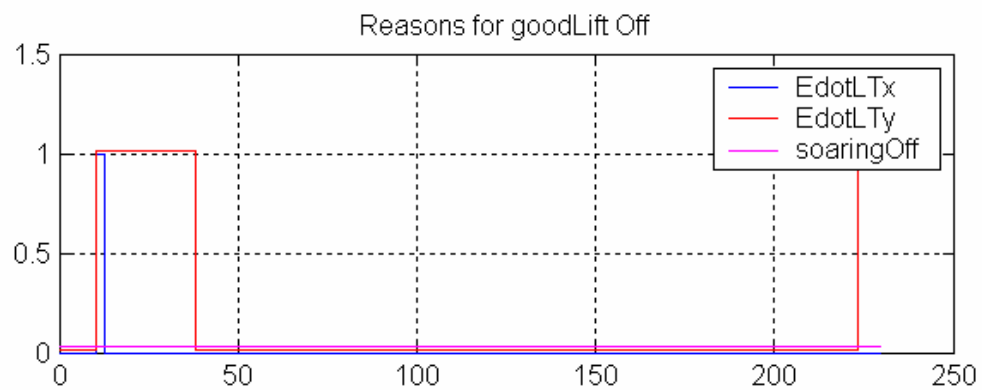
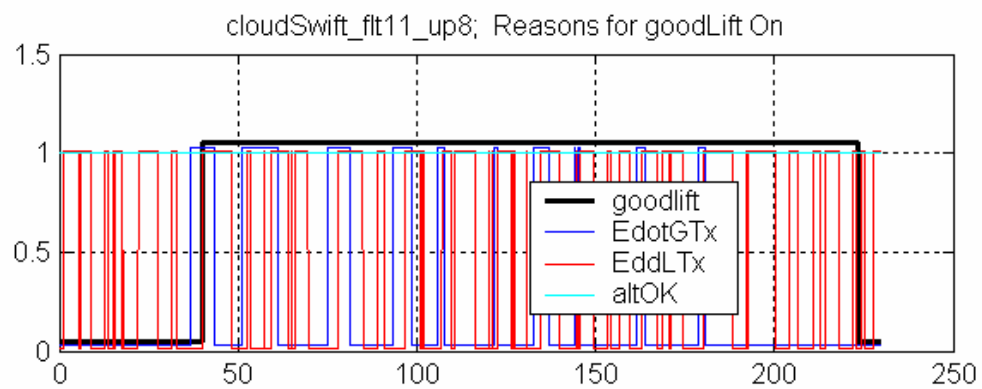
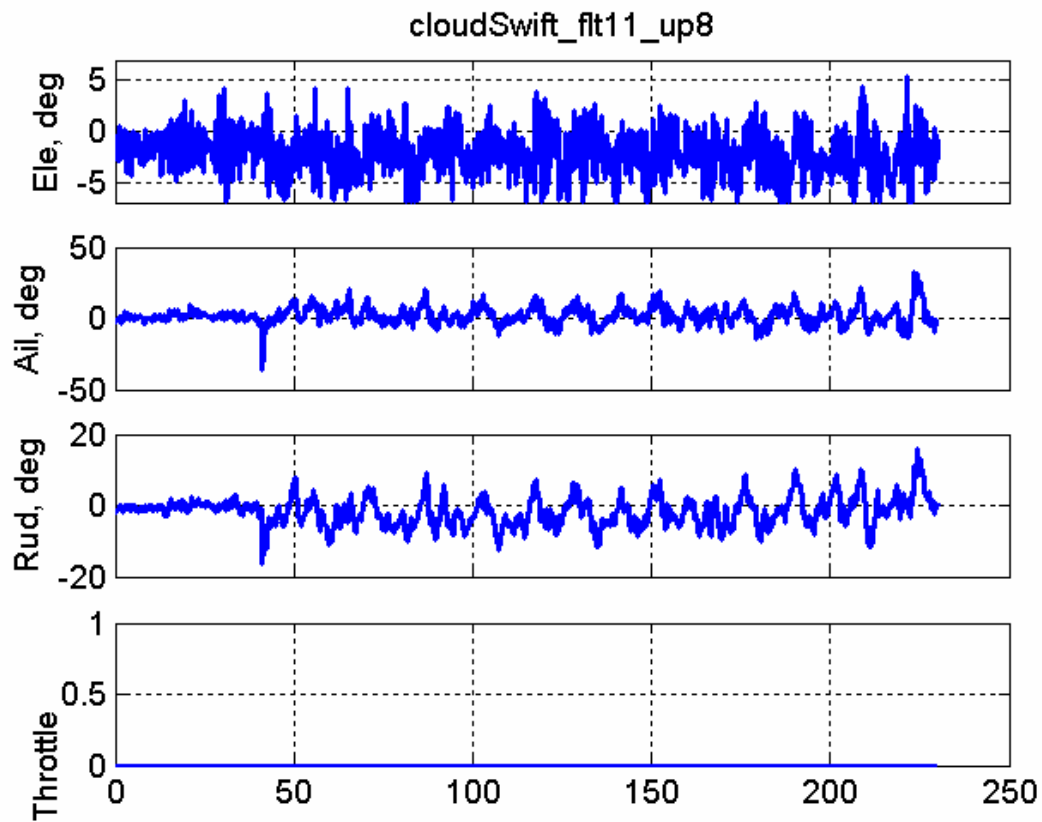
Lift seems to move. Fair centering. Spiralgraph pattern.

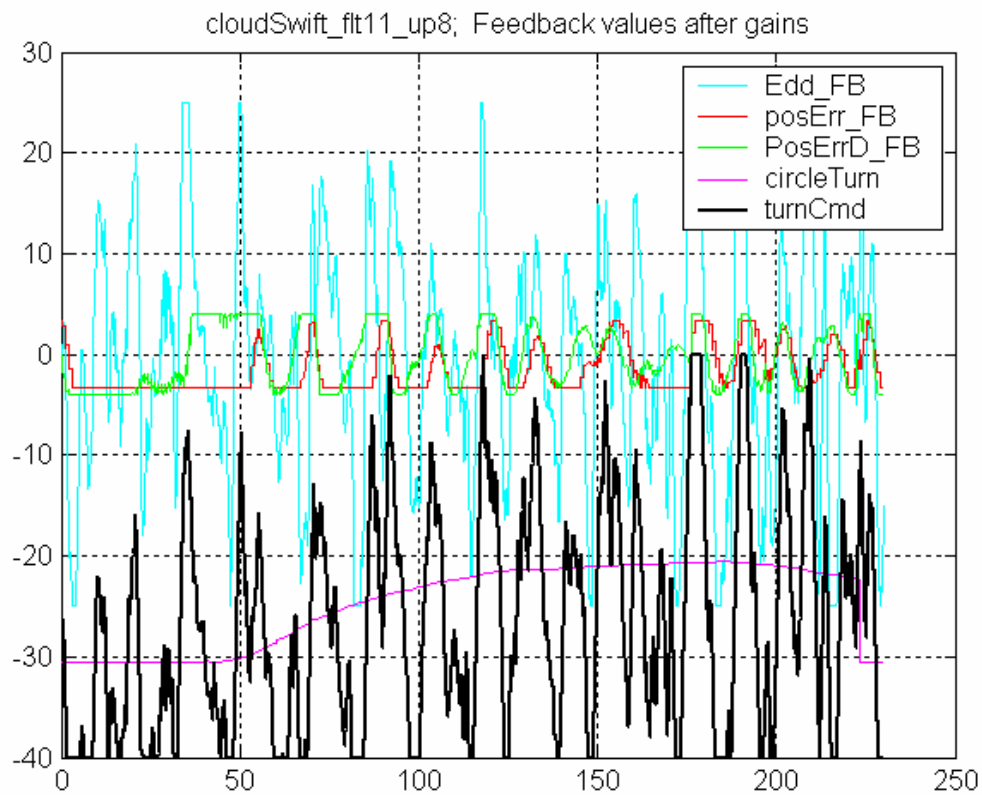
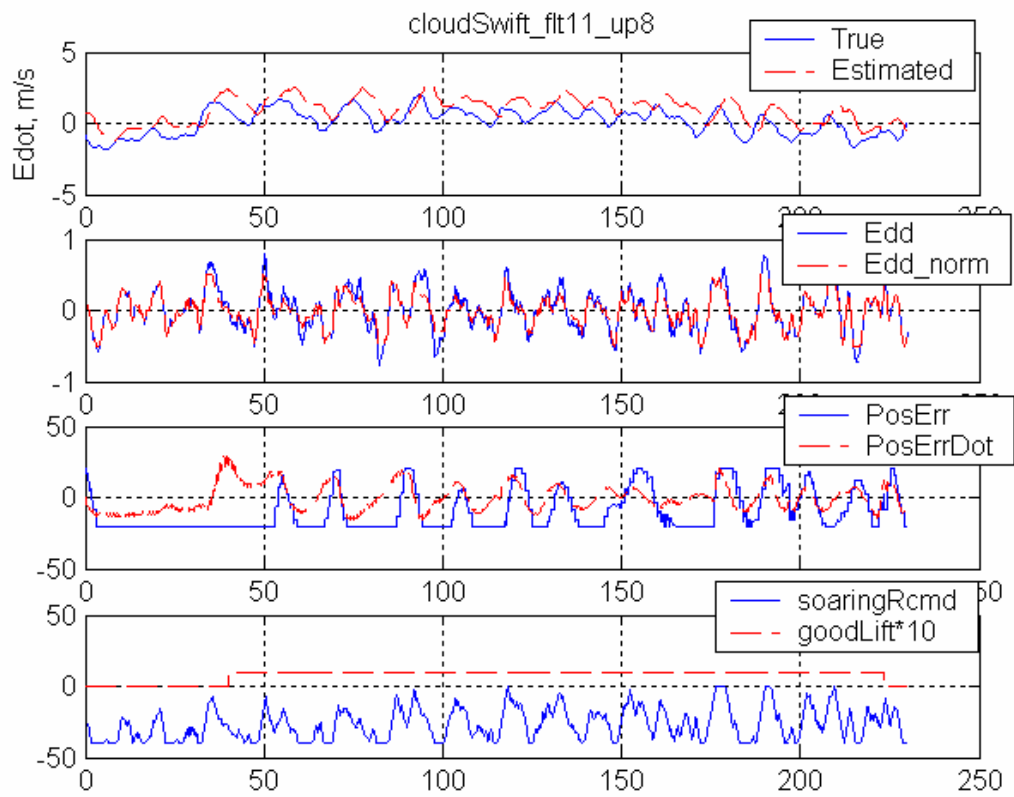






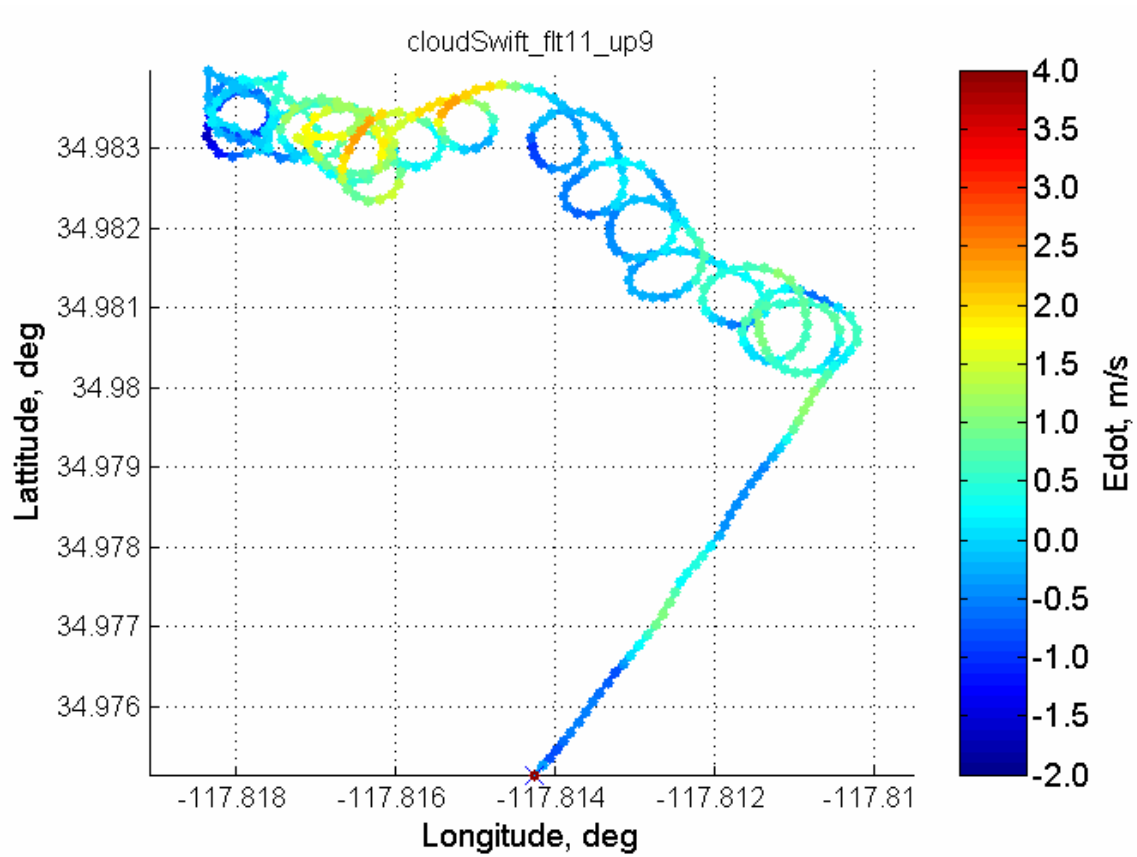


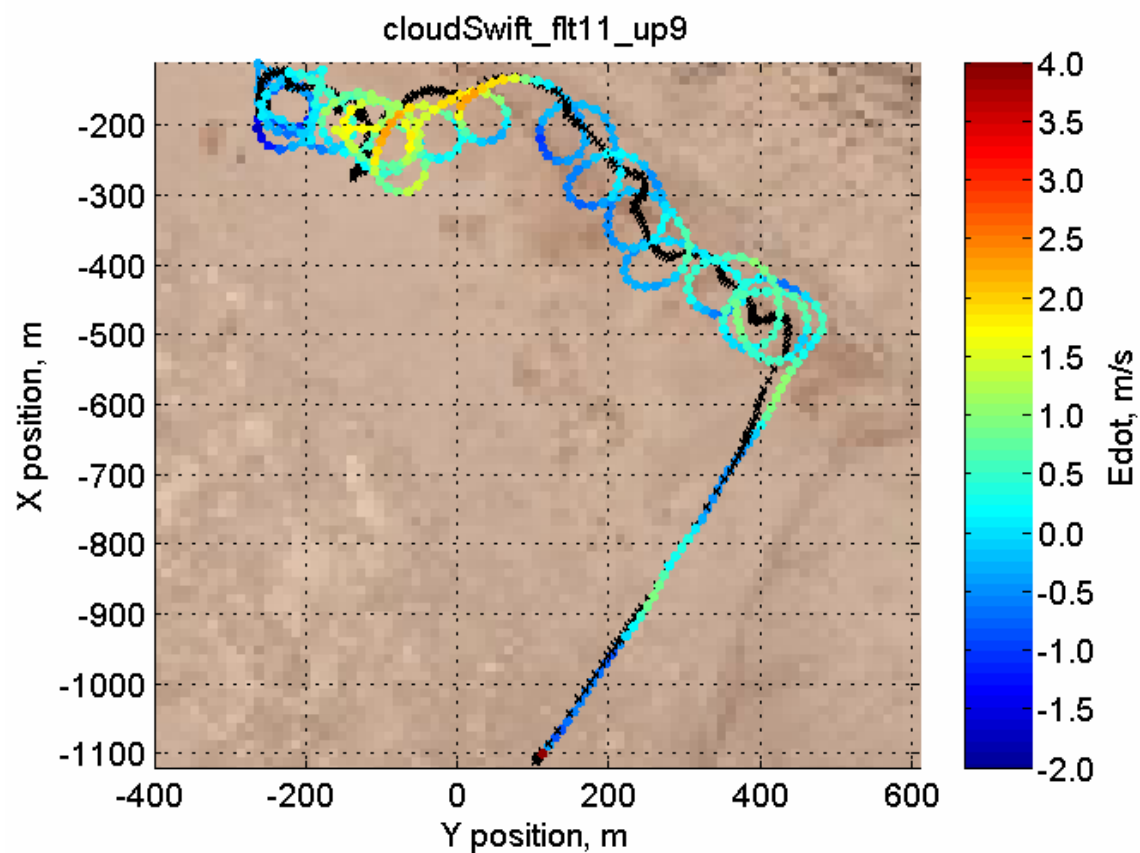
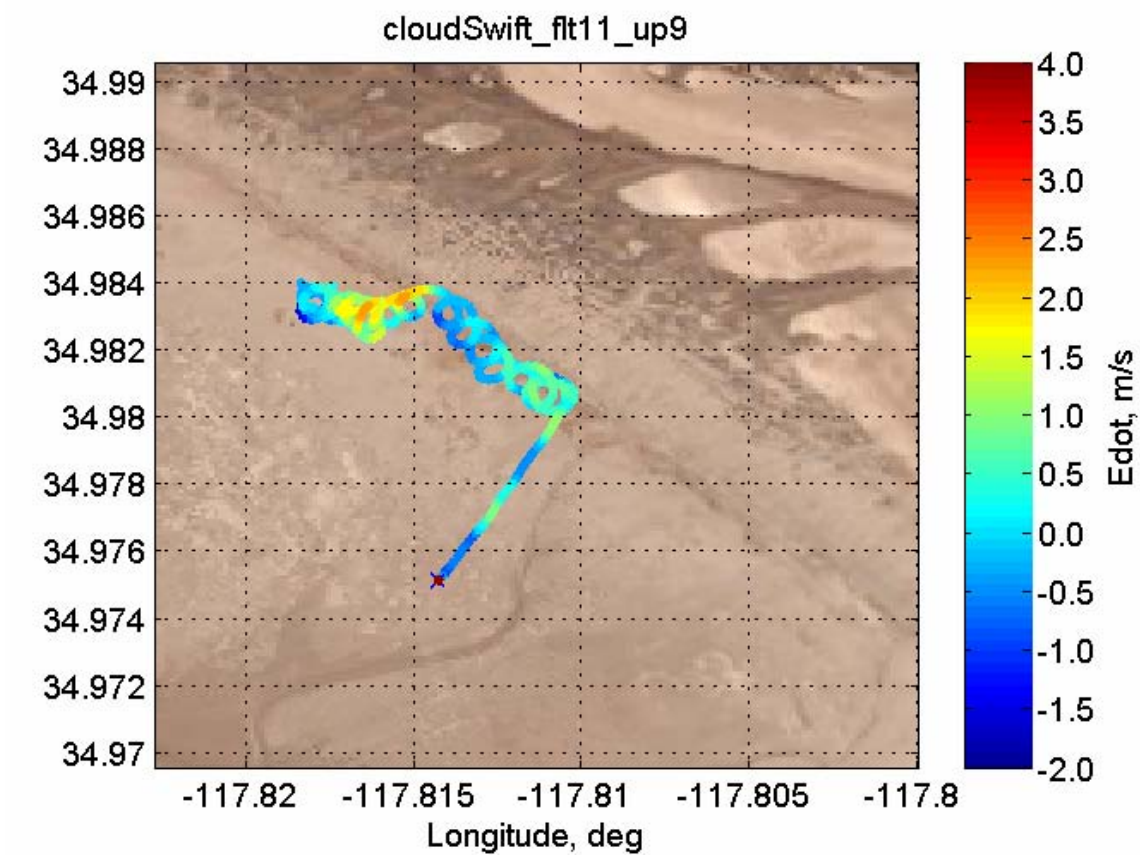


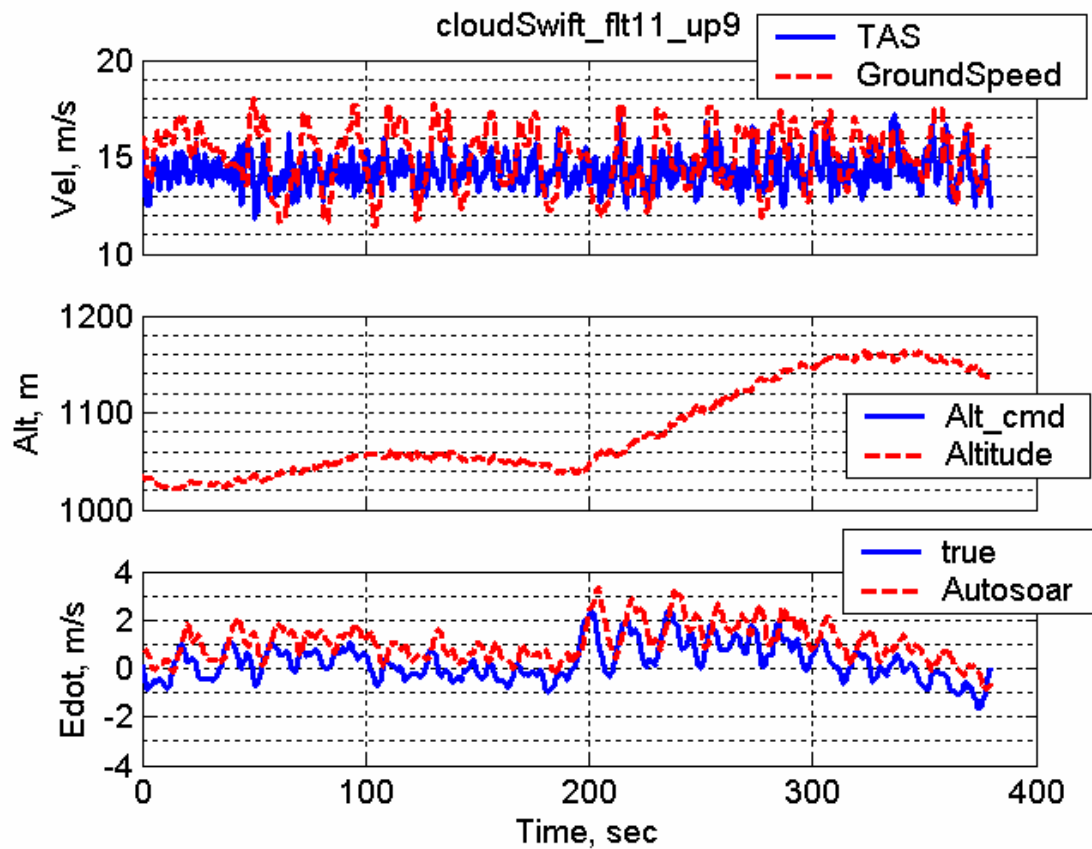
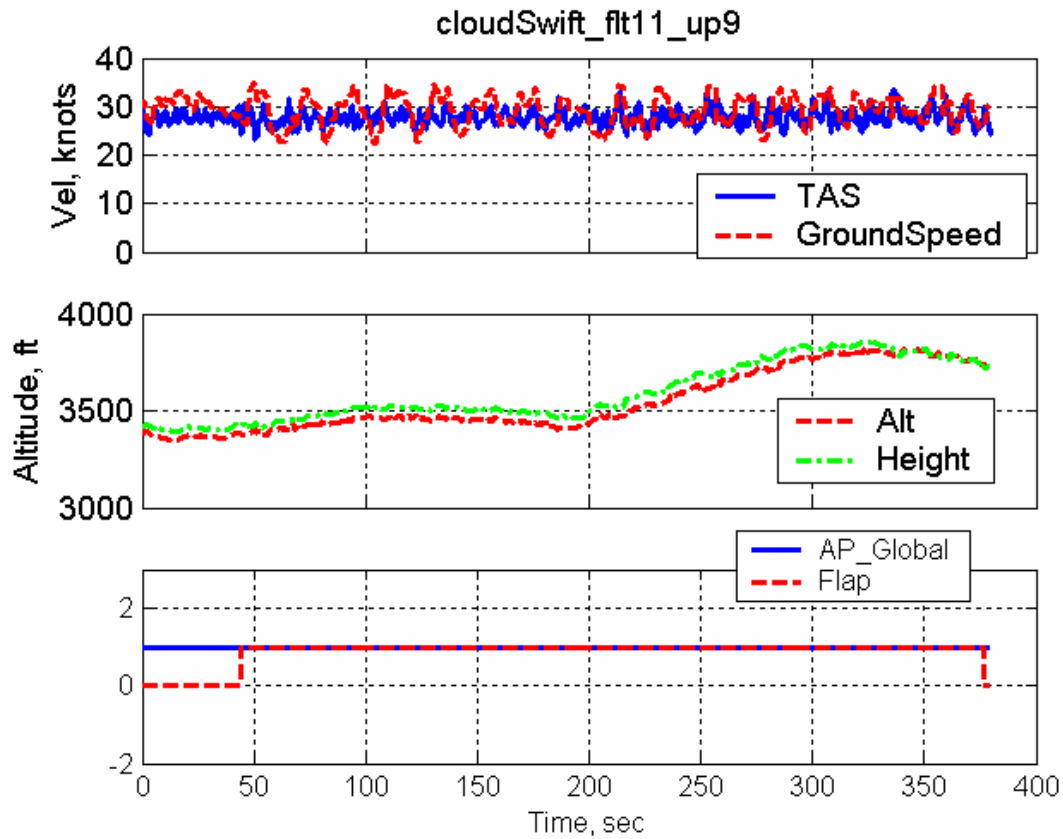


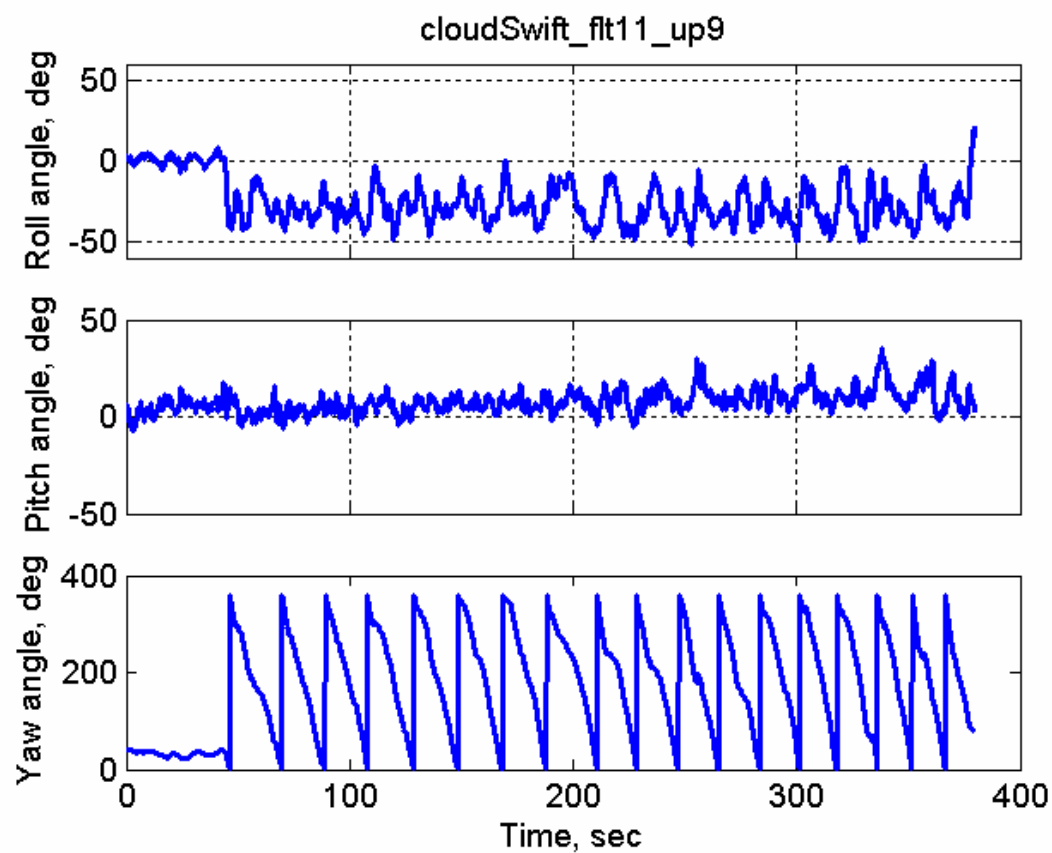
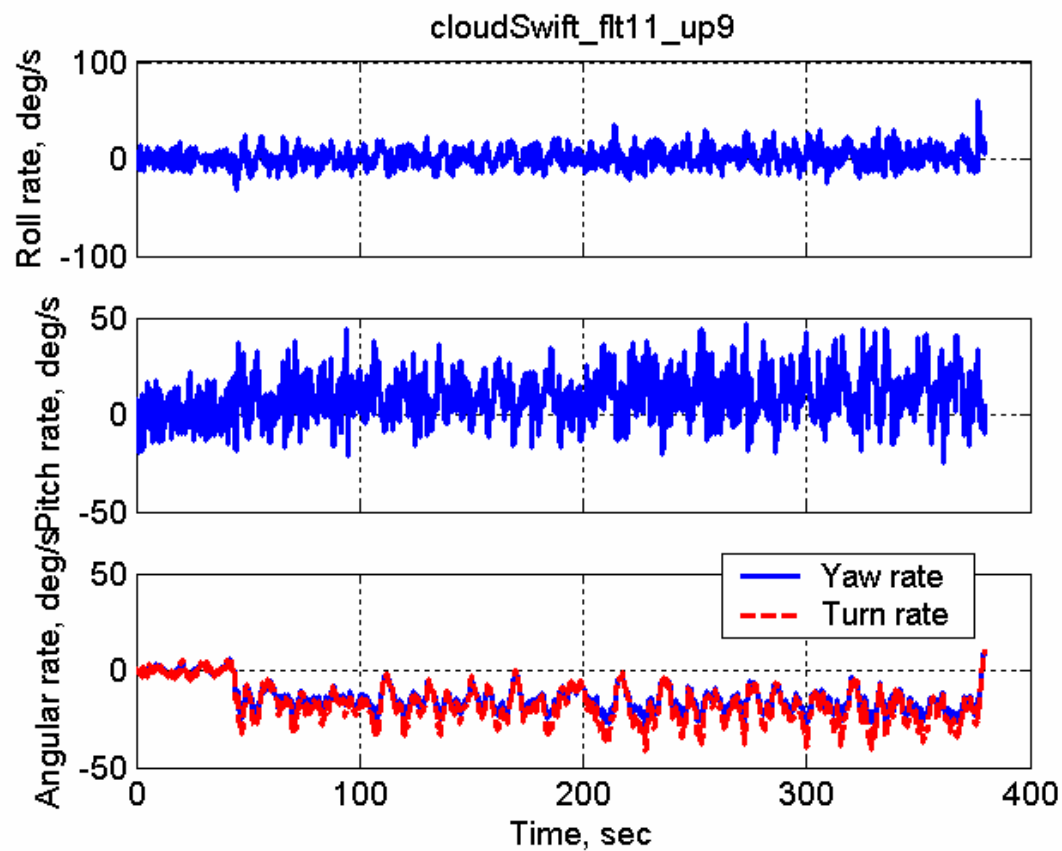
Flight 11, updraft 9

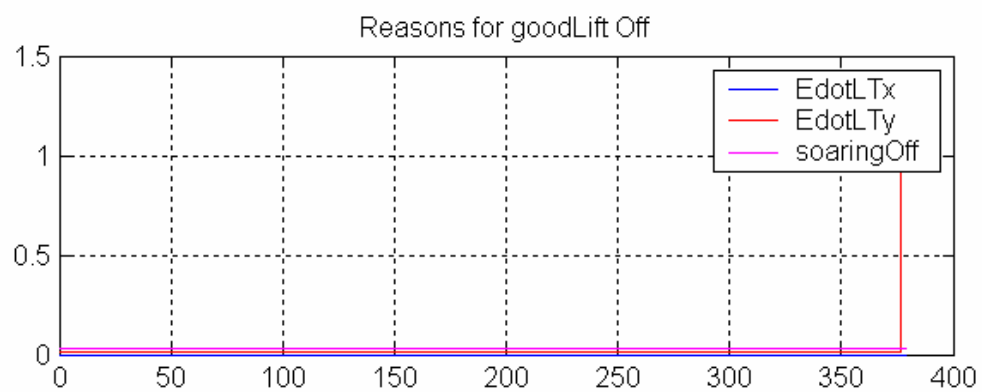
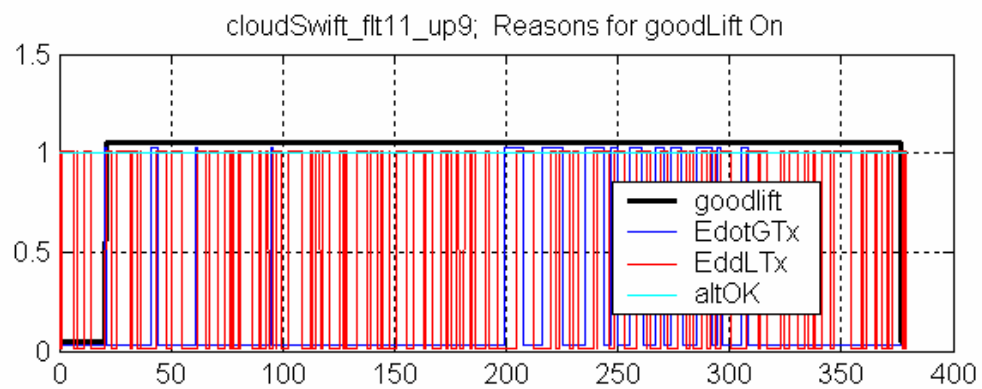
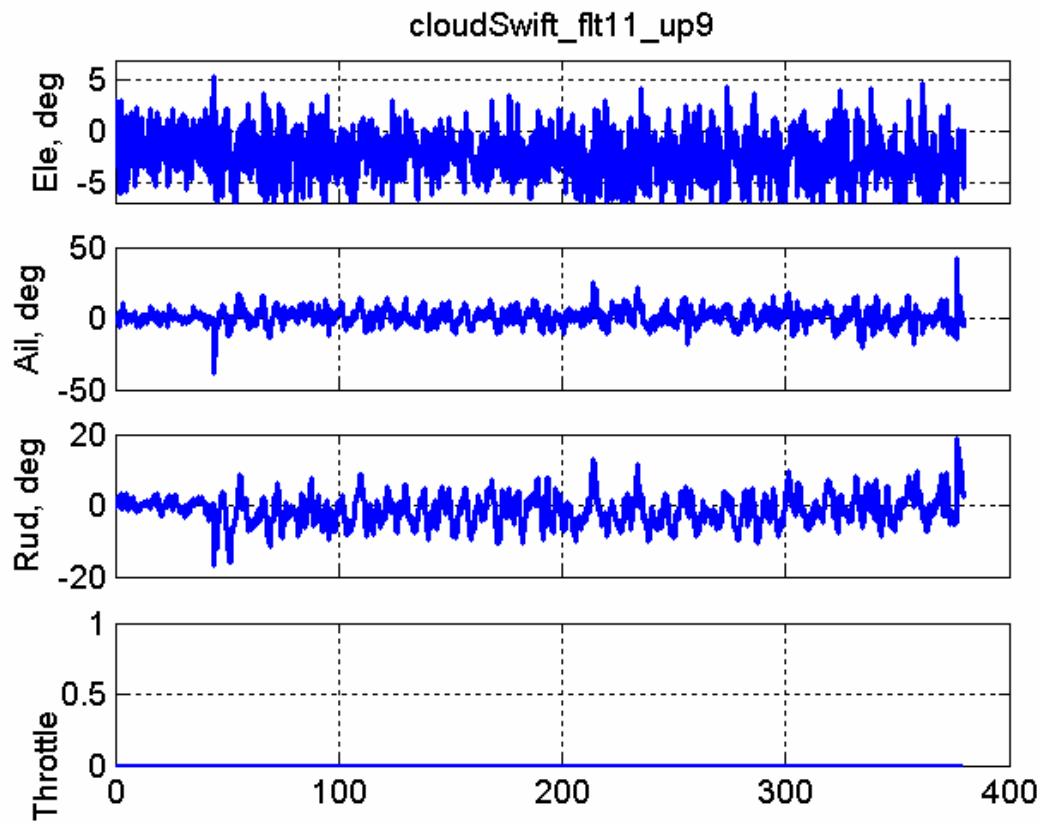
Average. finds thermal, almost loses it, finds it again.

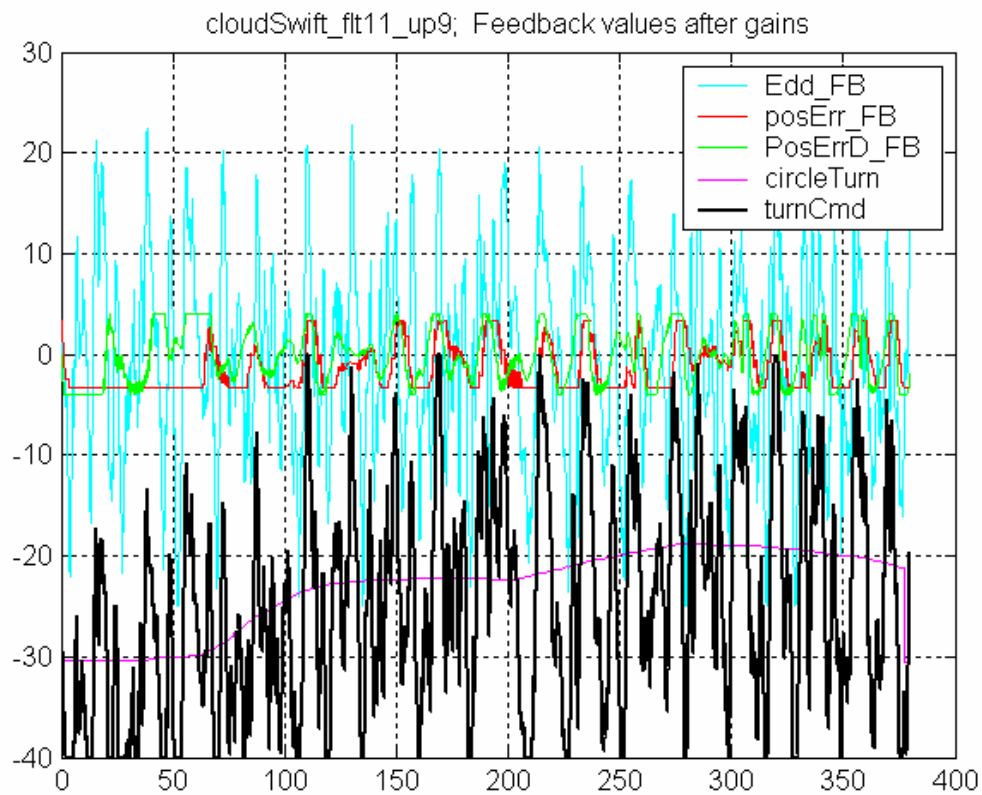
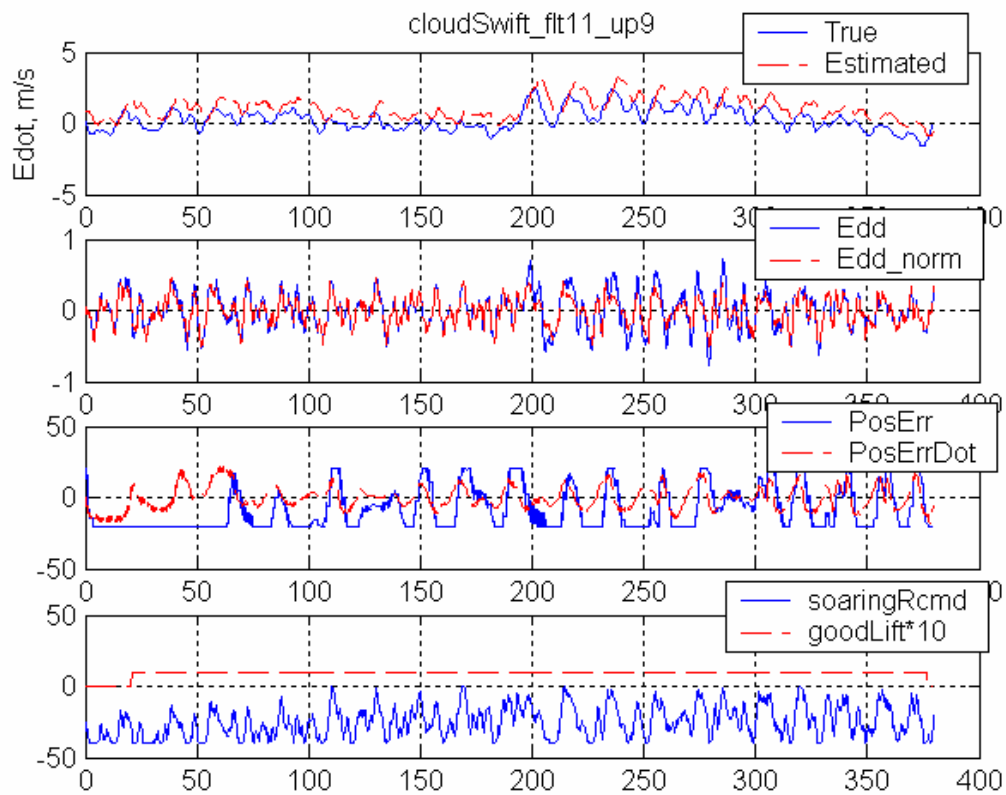




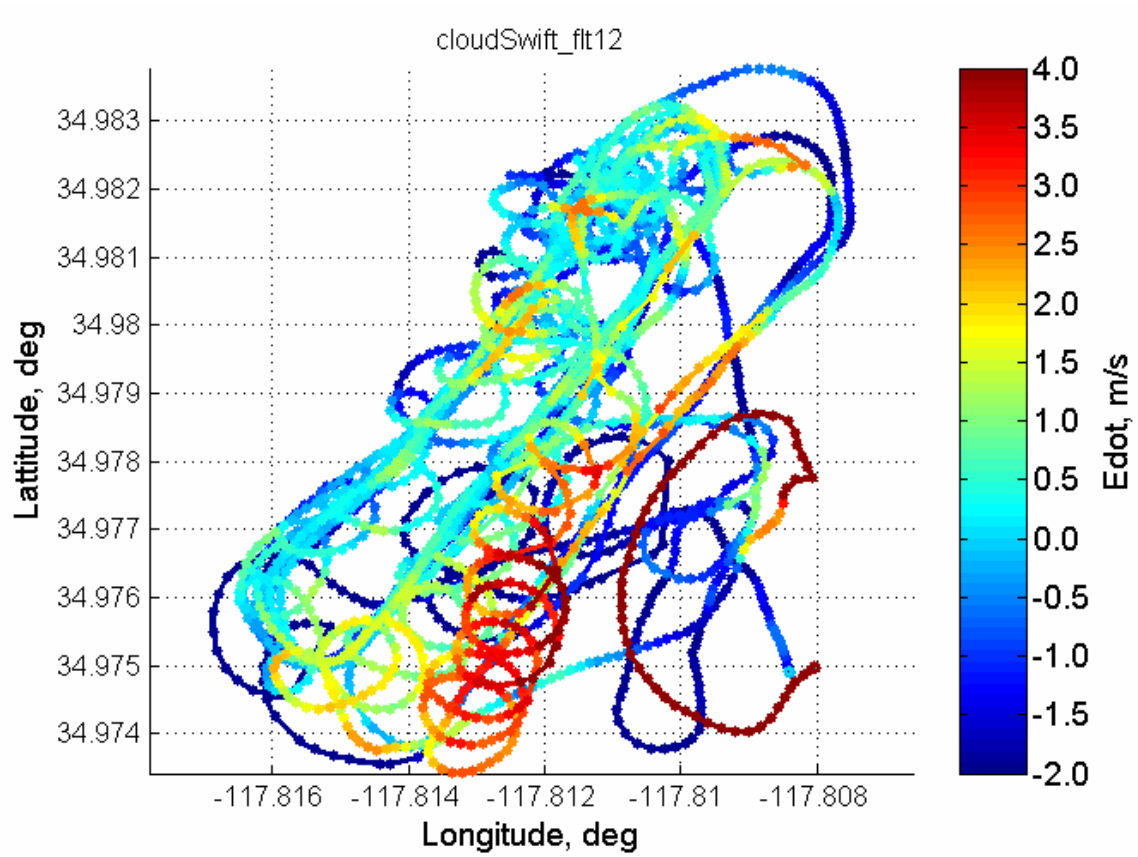


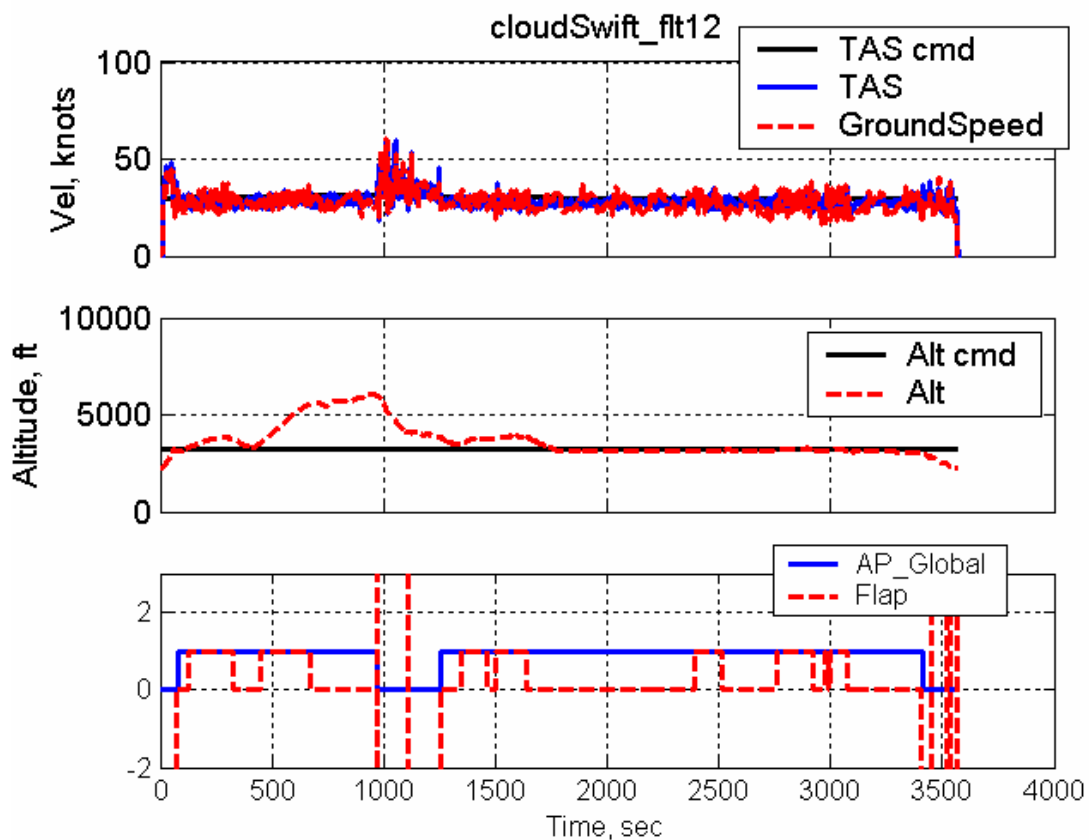
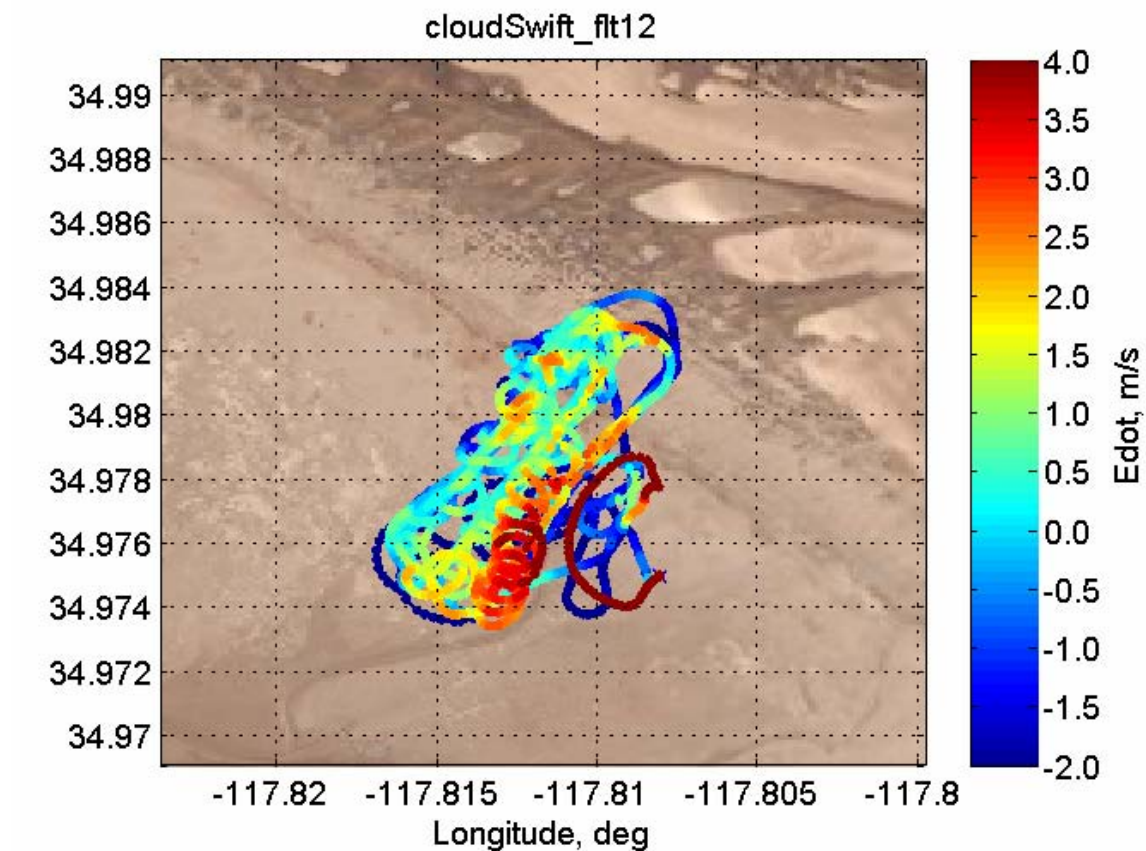


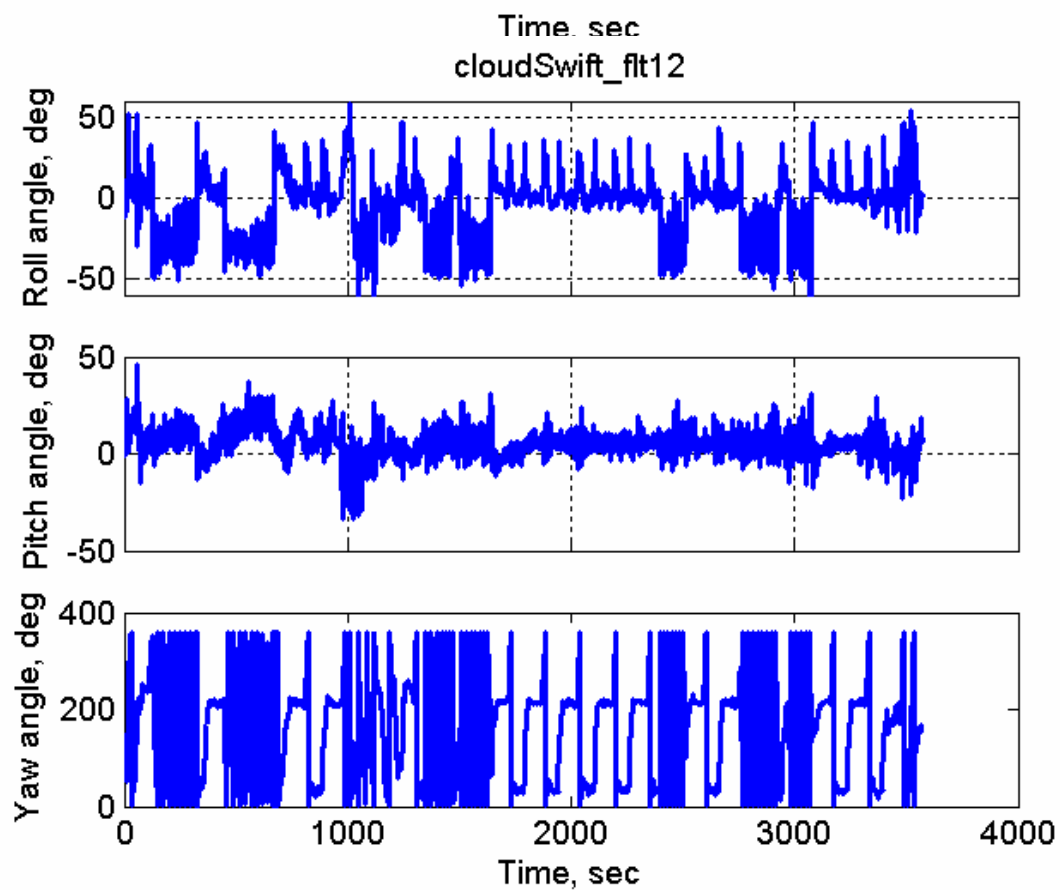
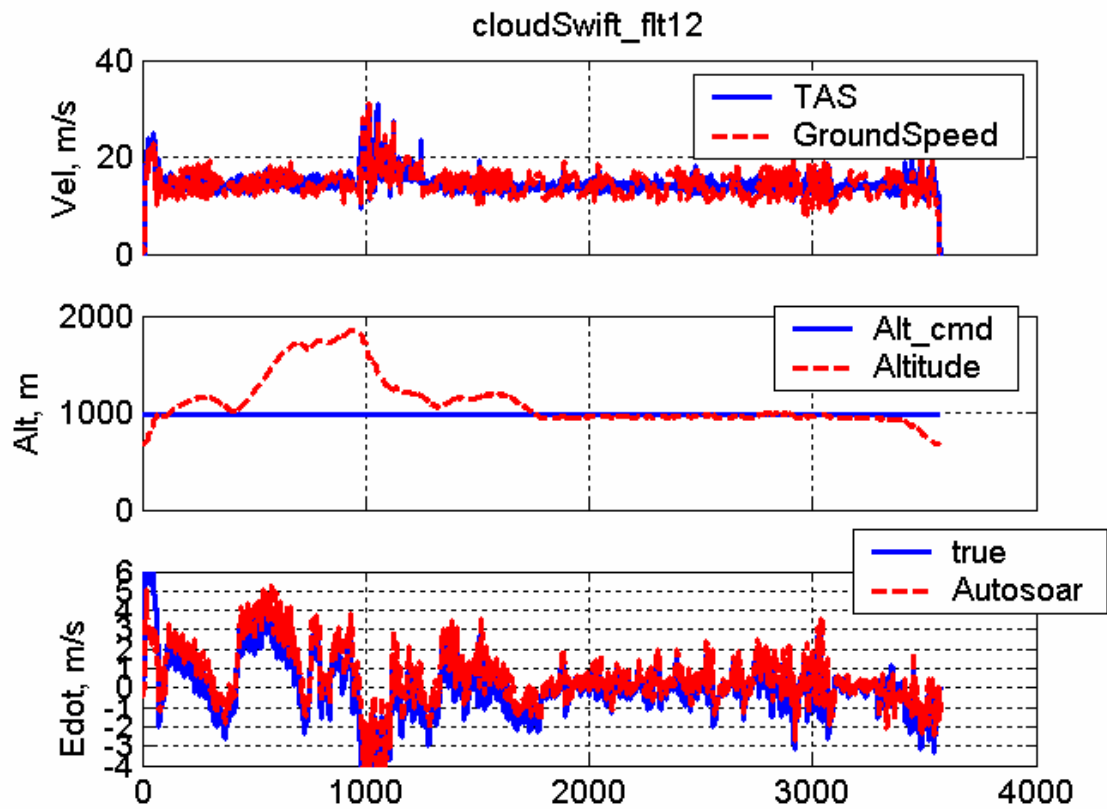


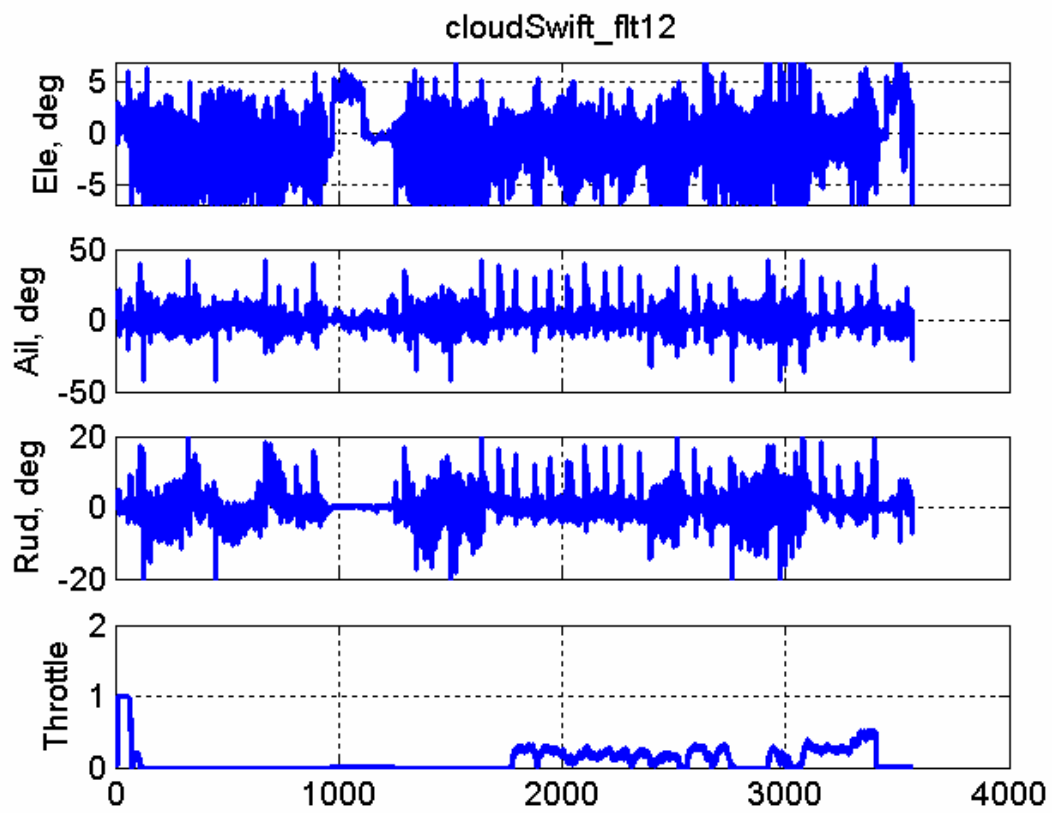


Flight 12



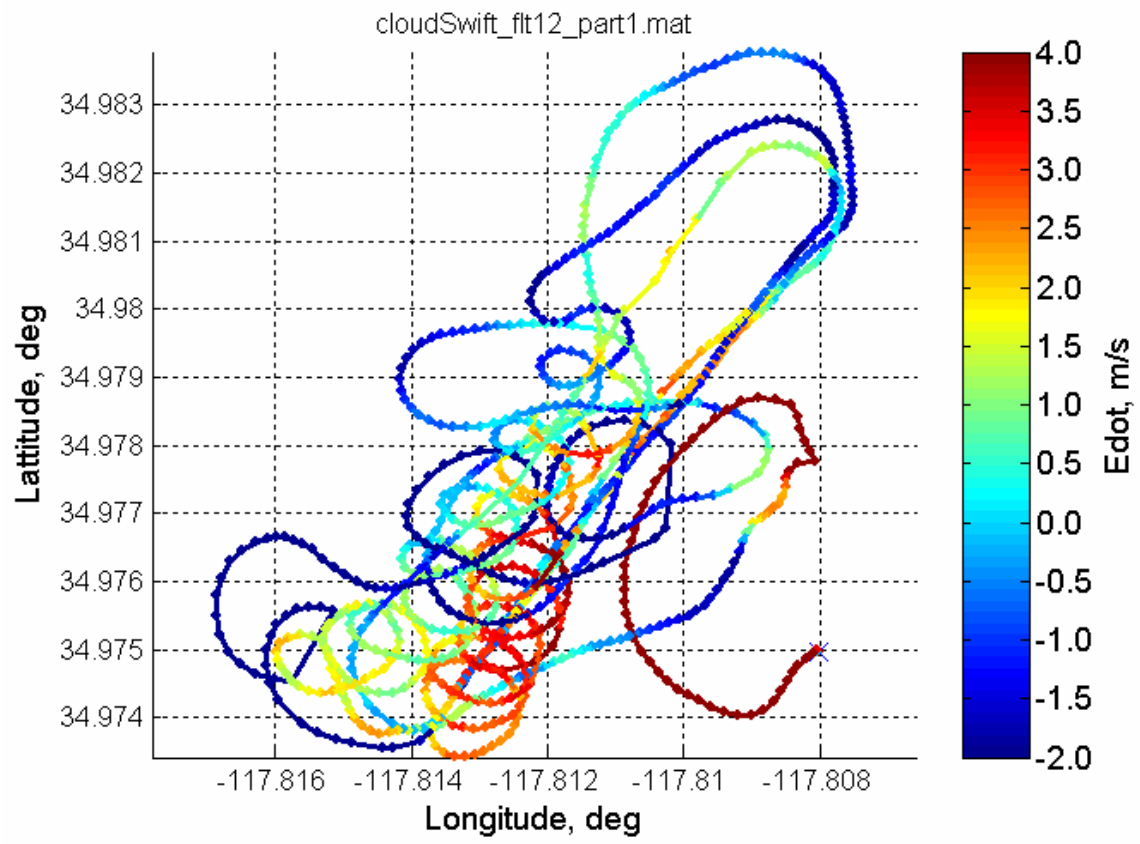


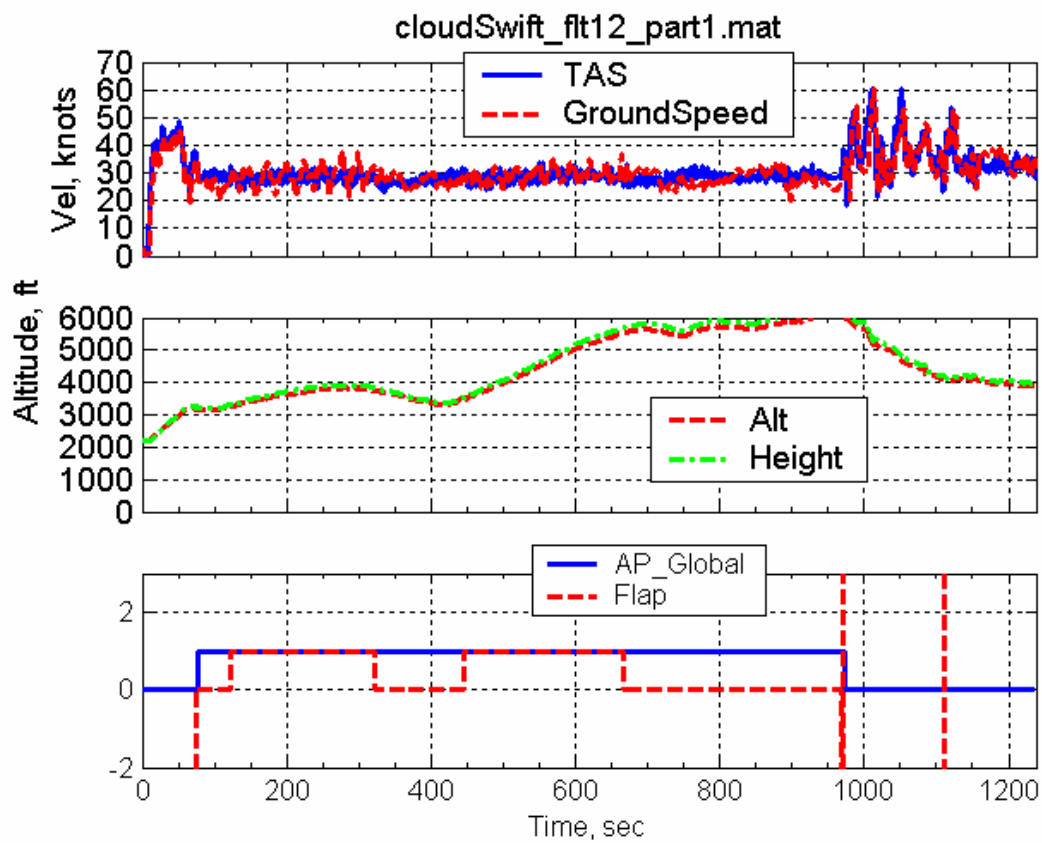
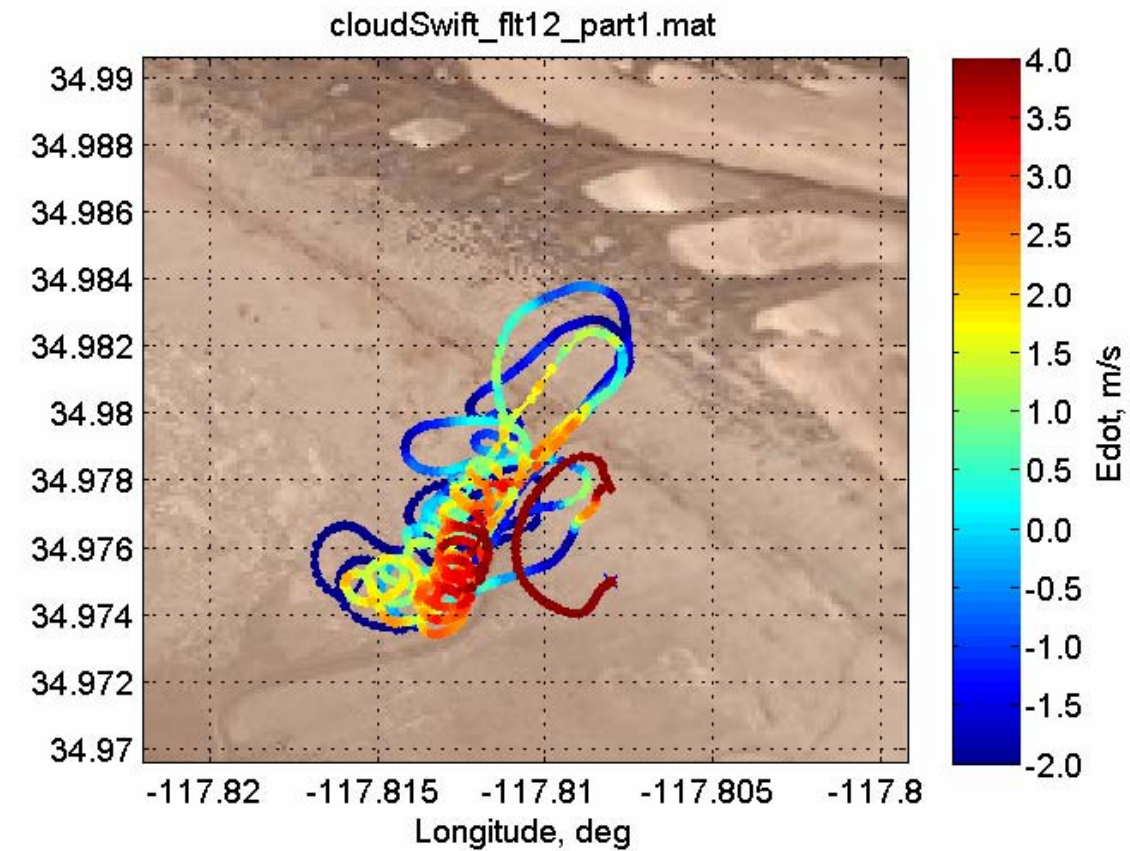




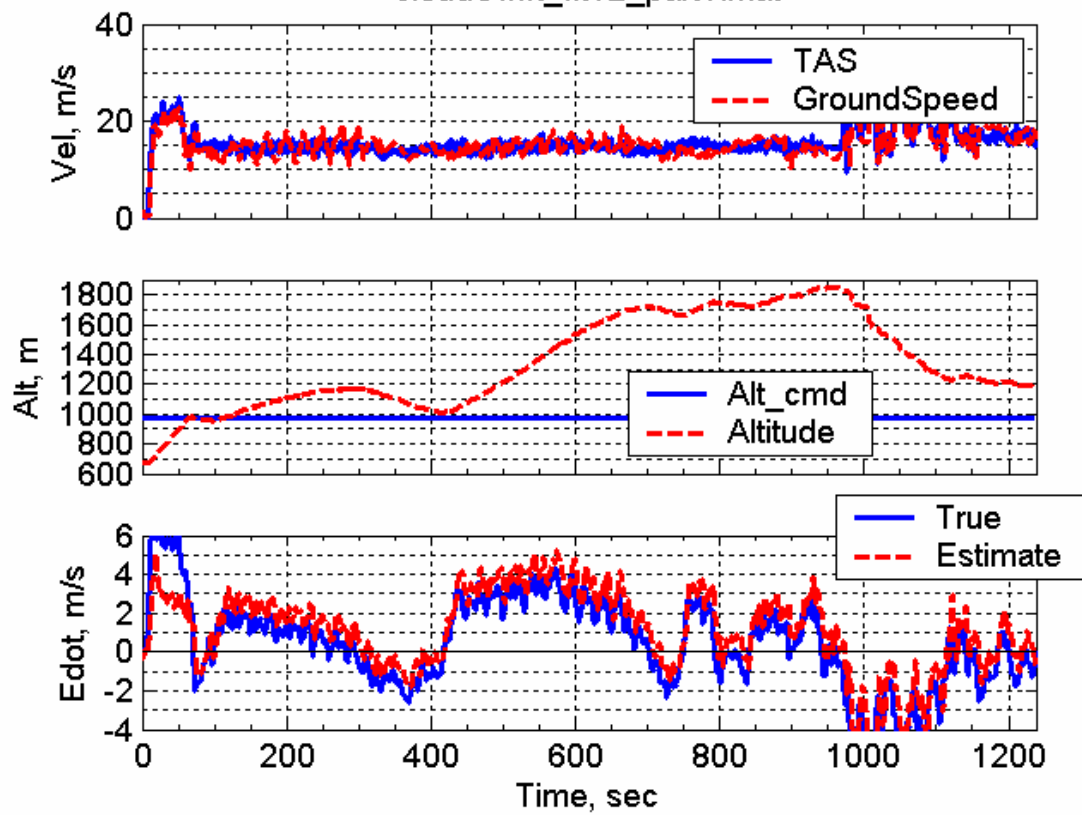
Flight 12, Part 1

1st 20min of flight.



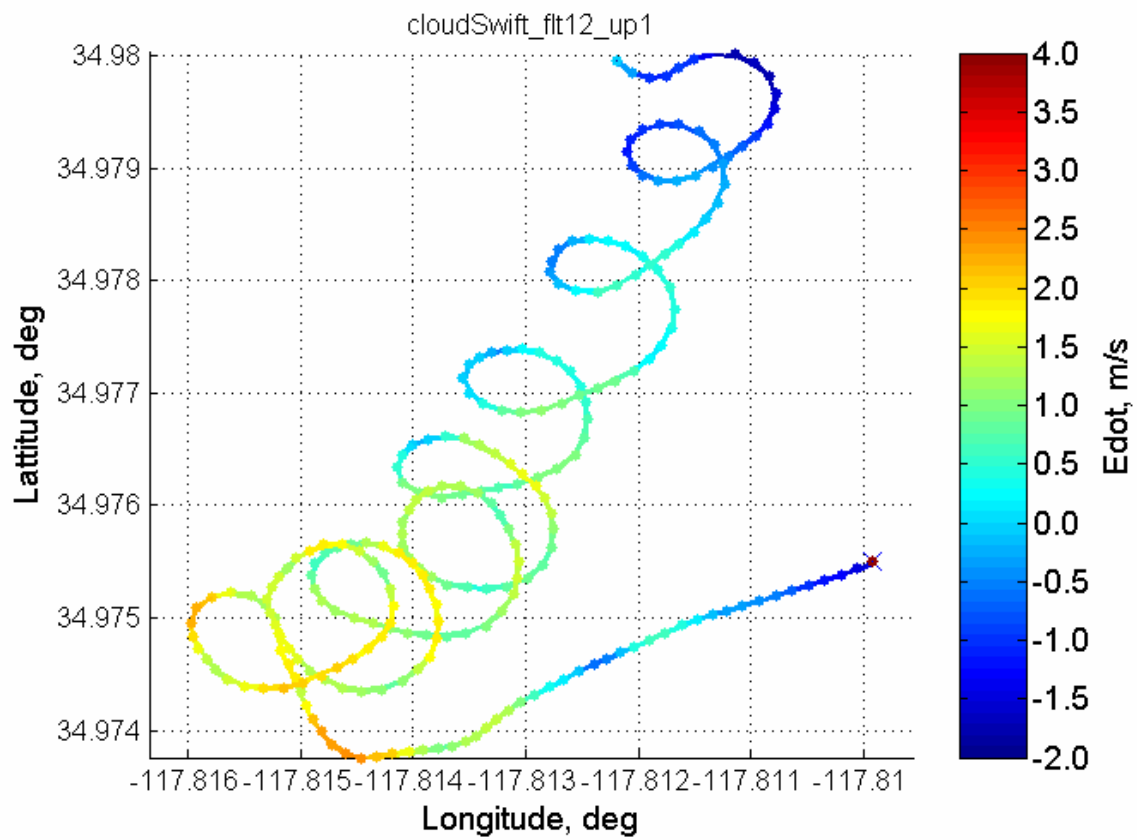


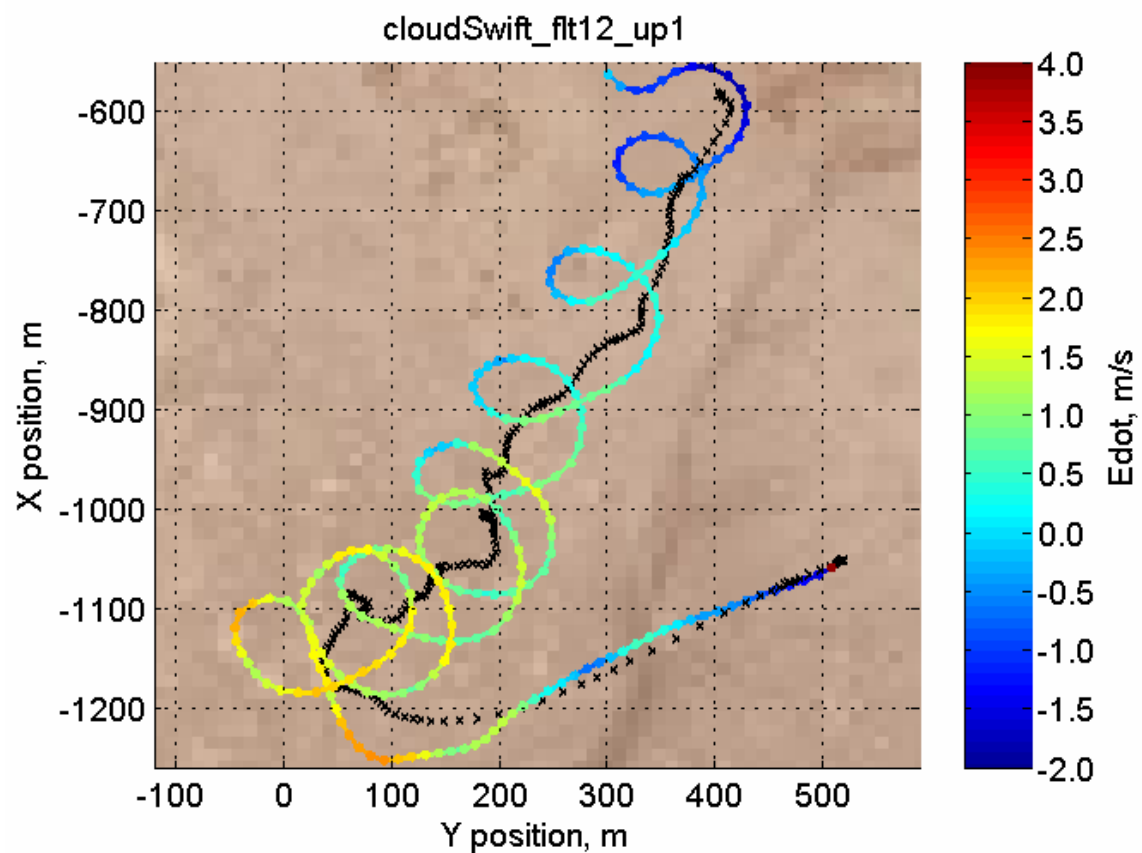
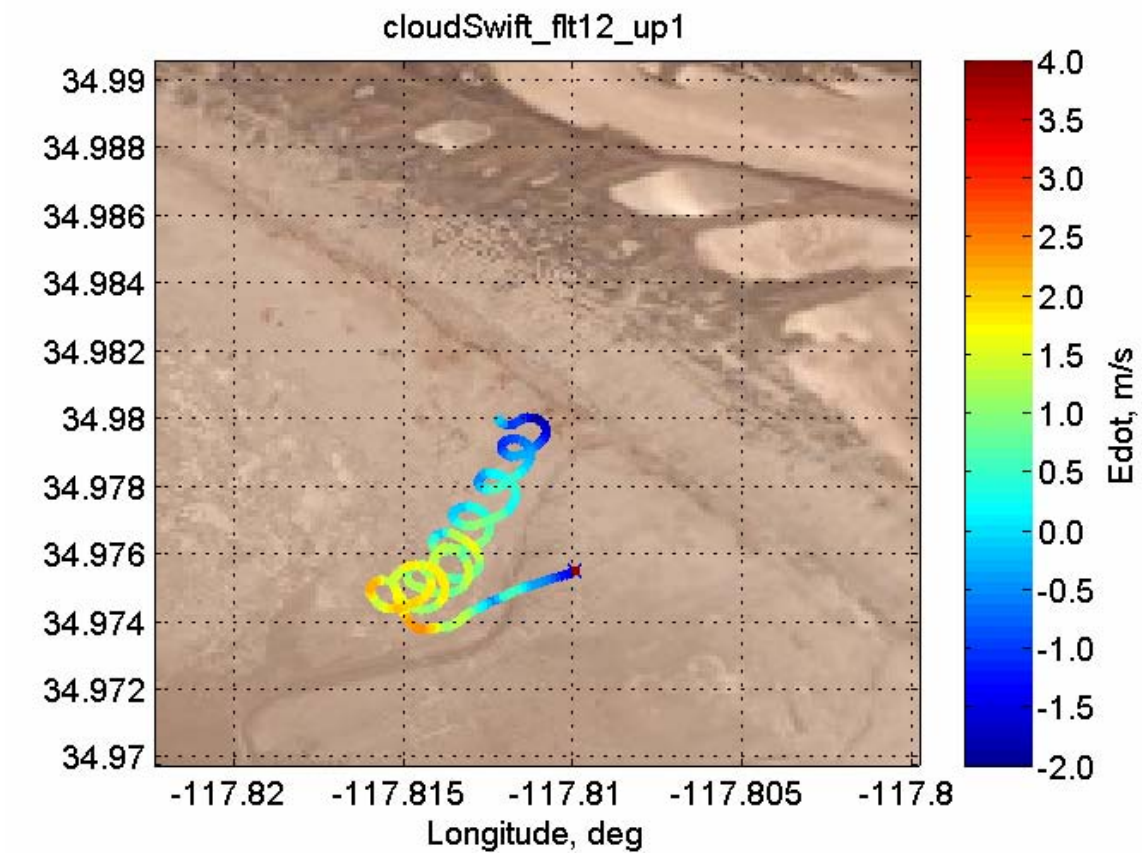
cloudSwift_fit12_part1.mat

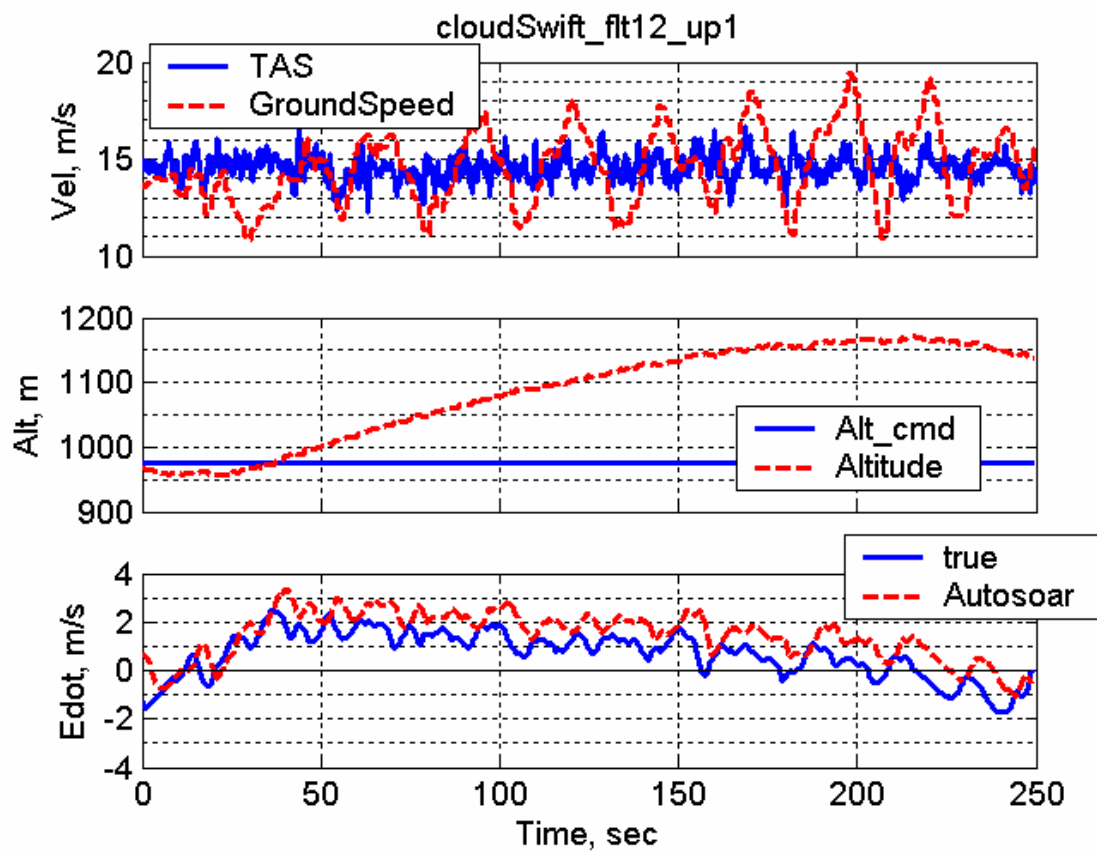
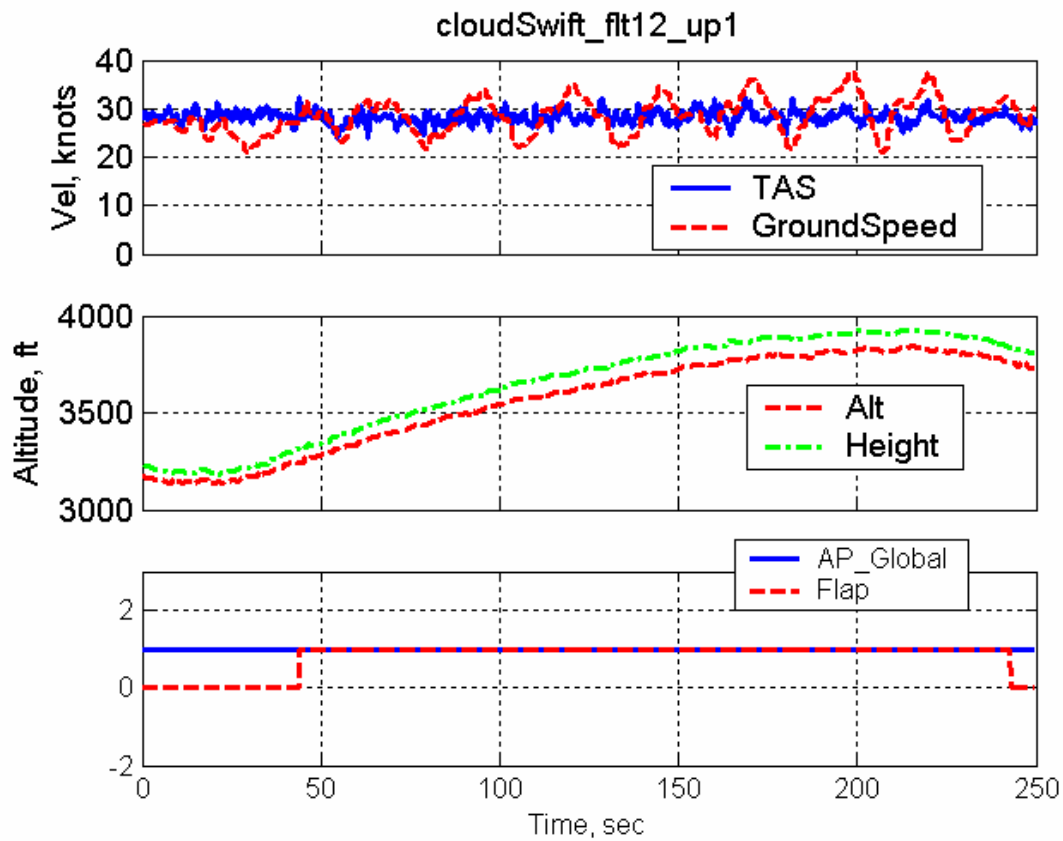


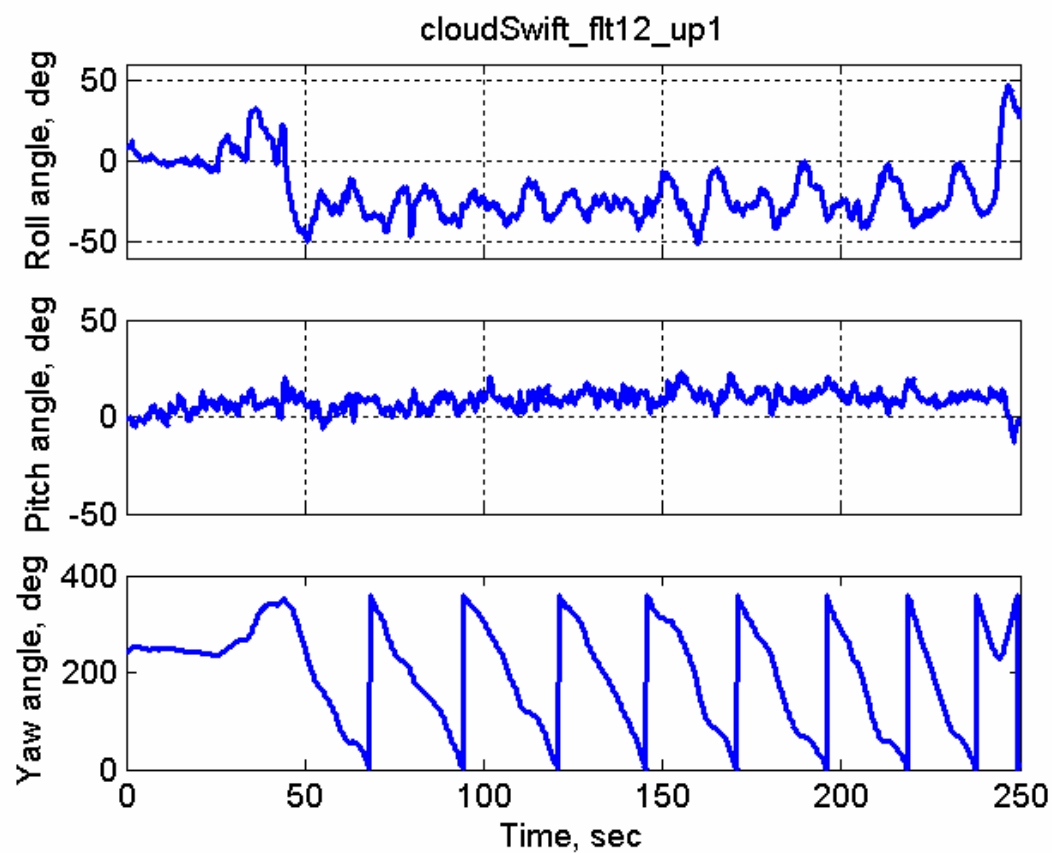
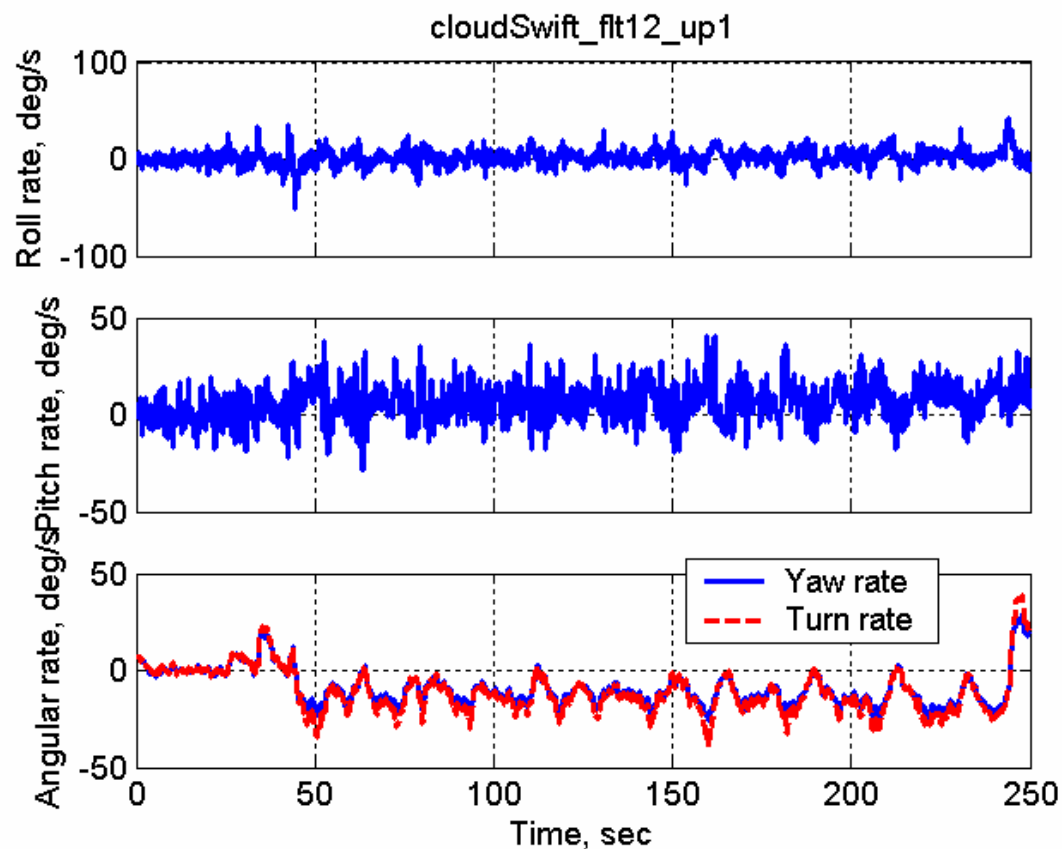
Flight 12, updraft 1

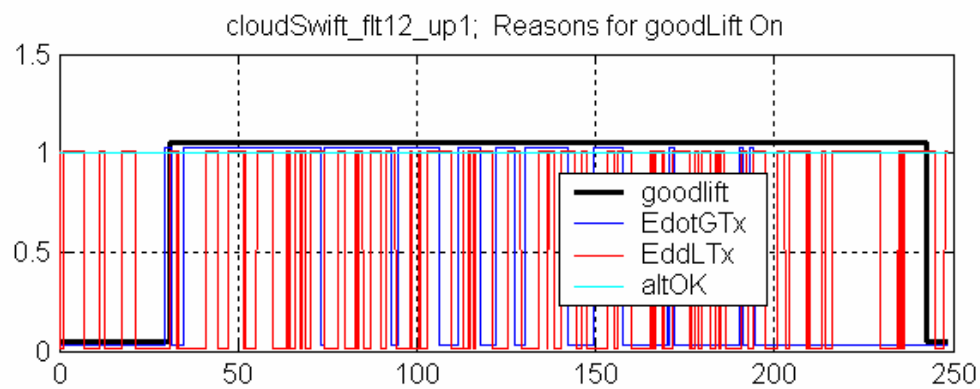
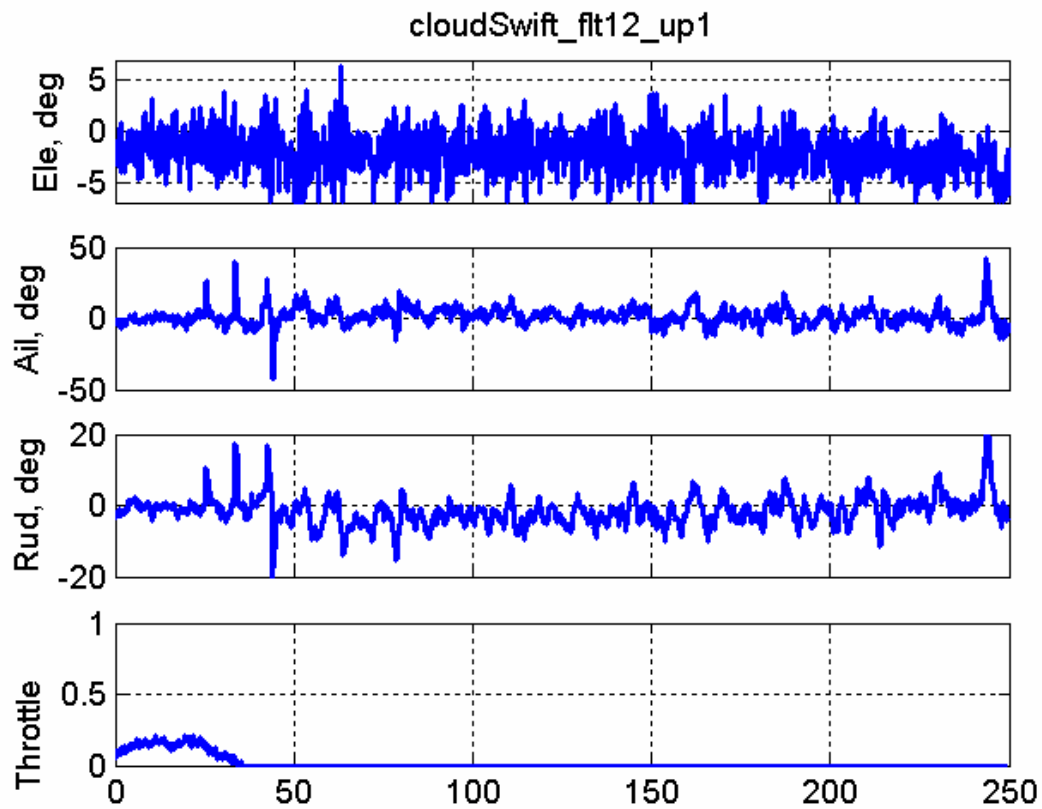
Seems to have gotten stuck on the edge. May need to reduce Edd gain. SW version 6_49.

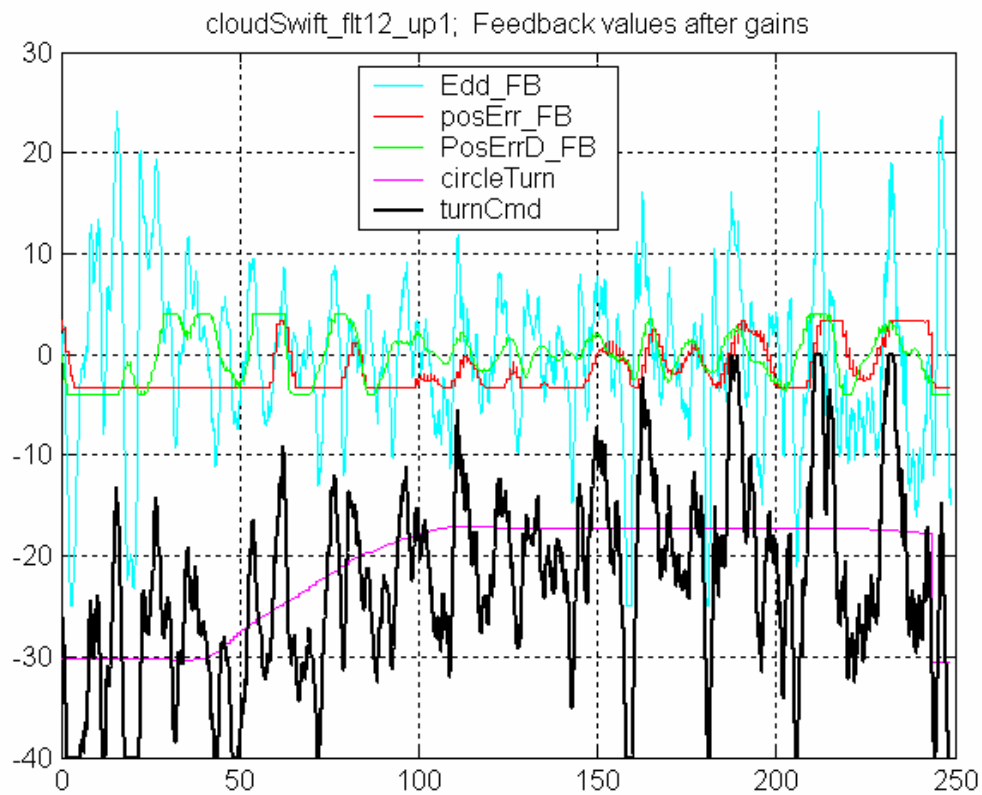
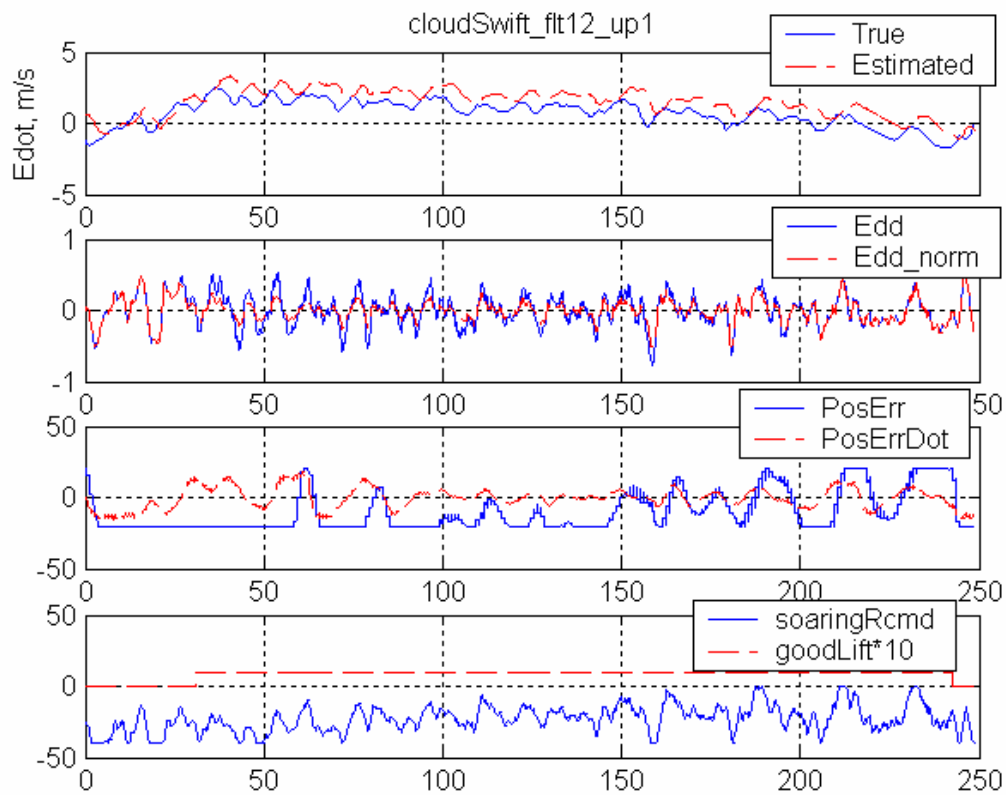






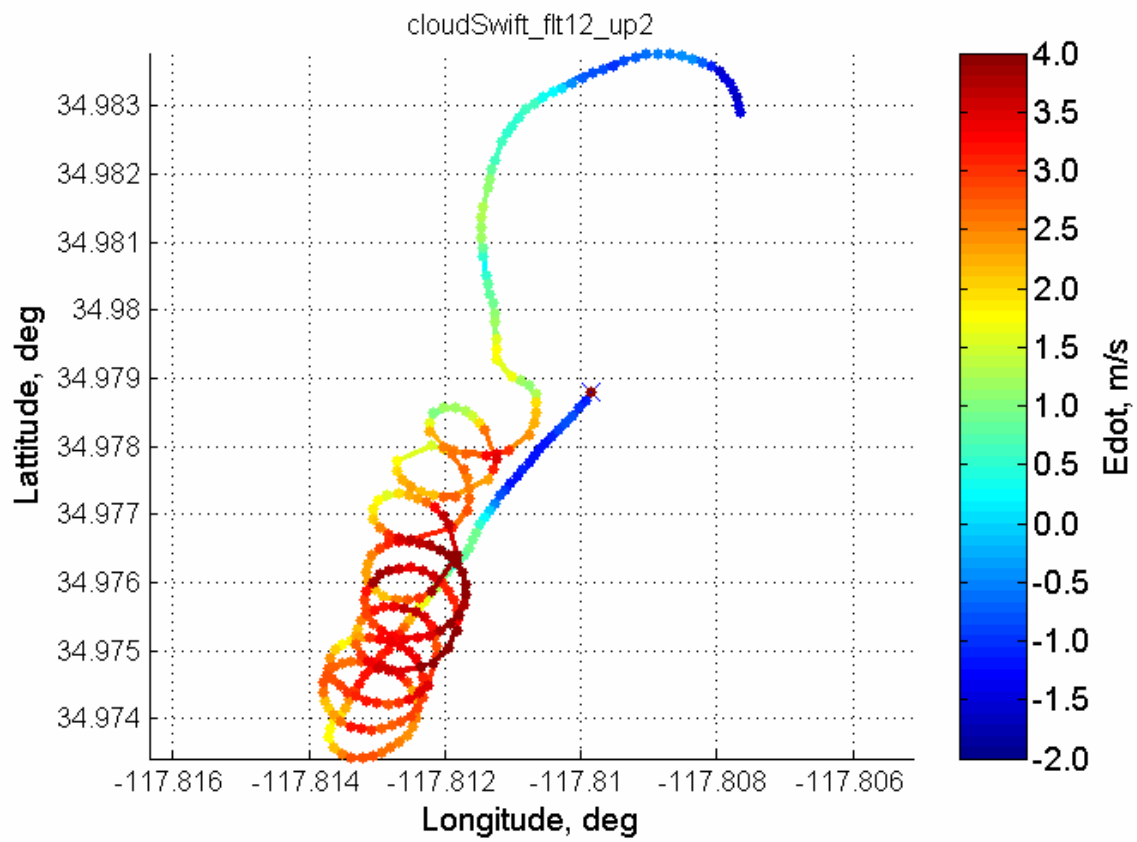


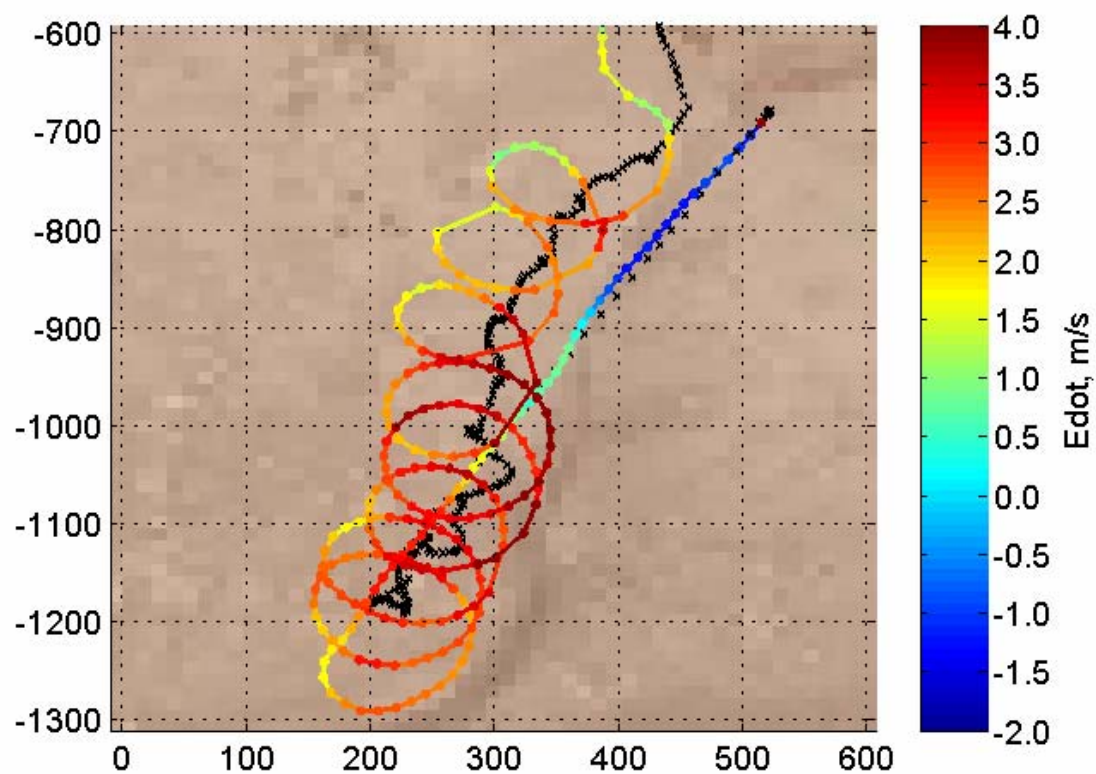
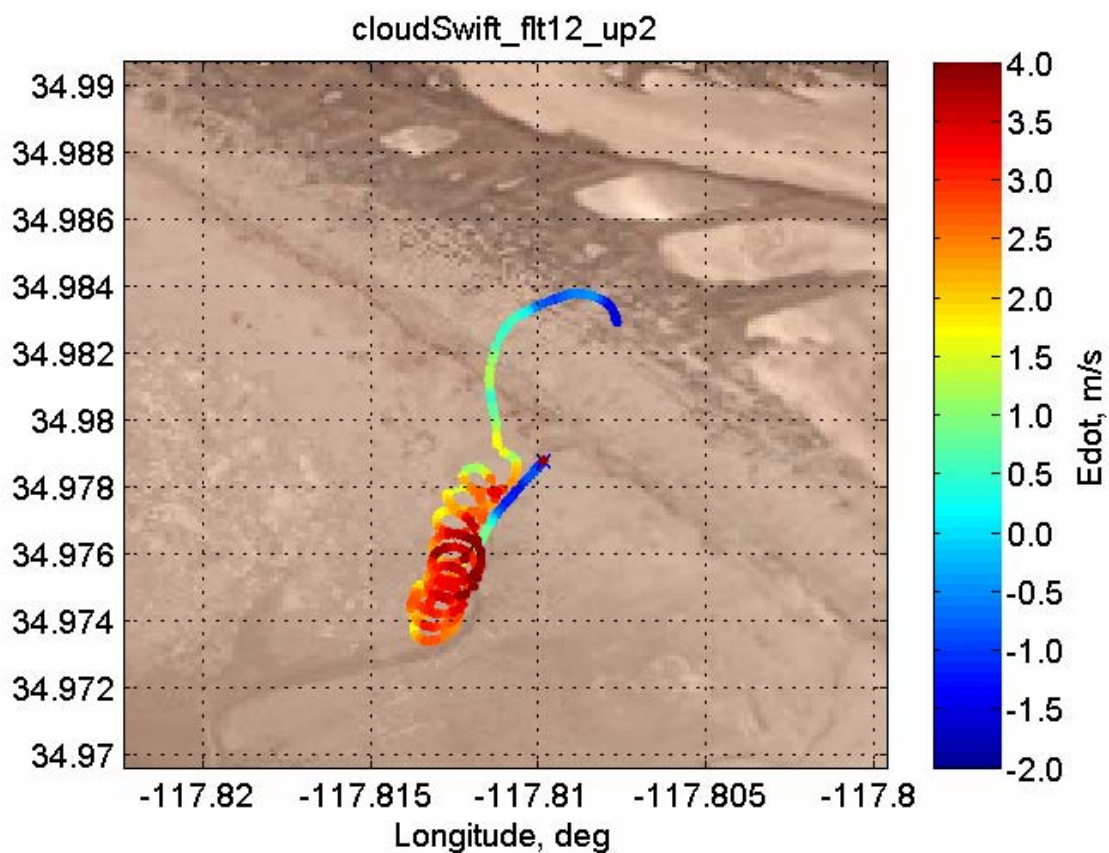


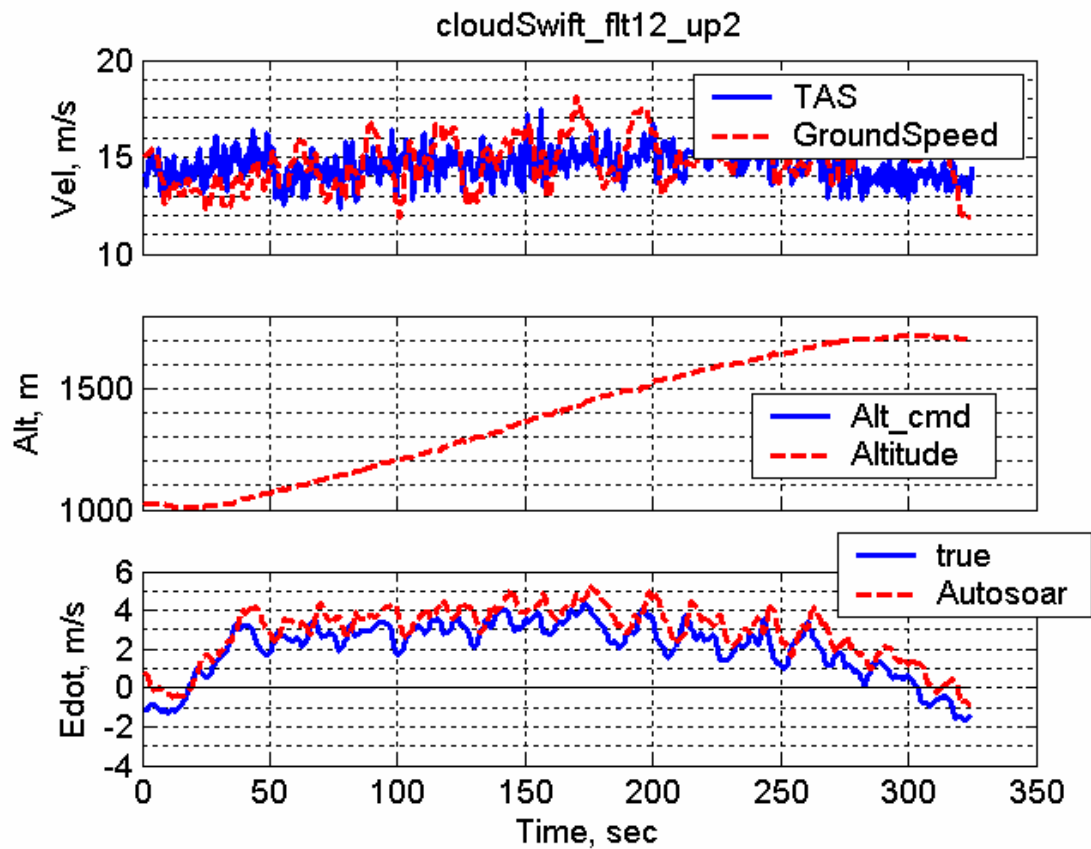
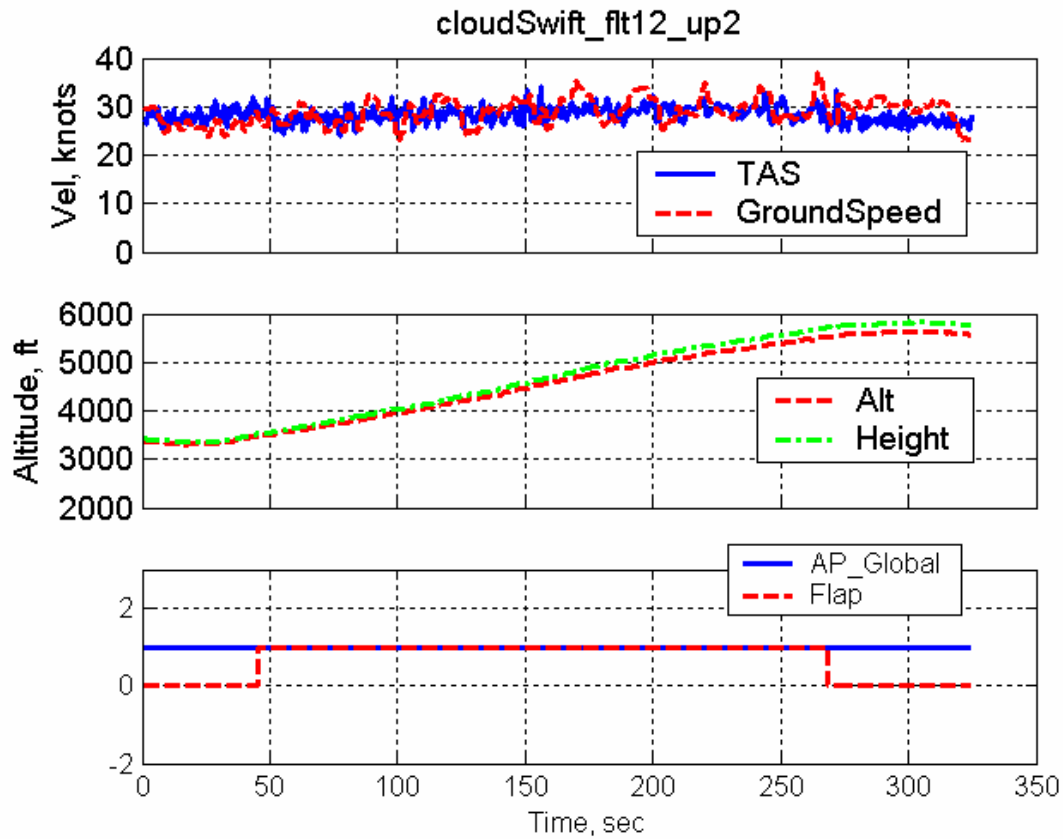


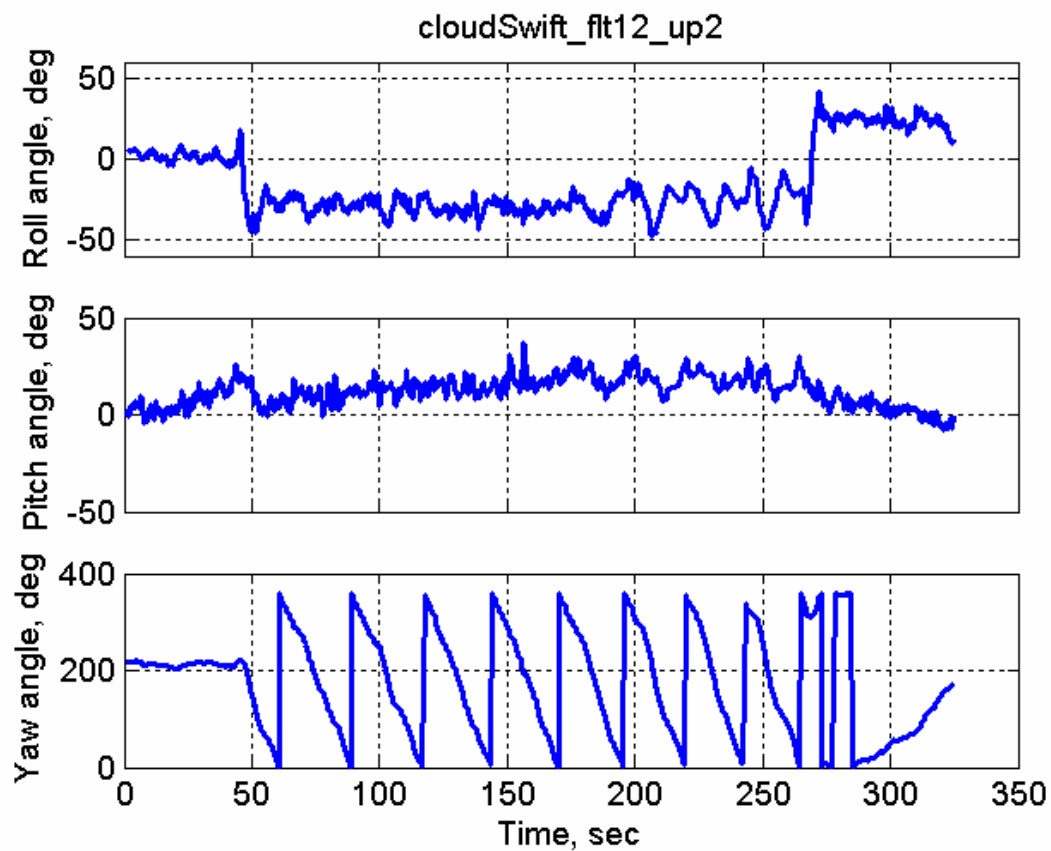
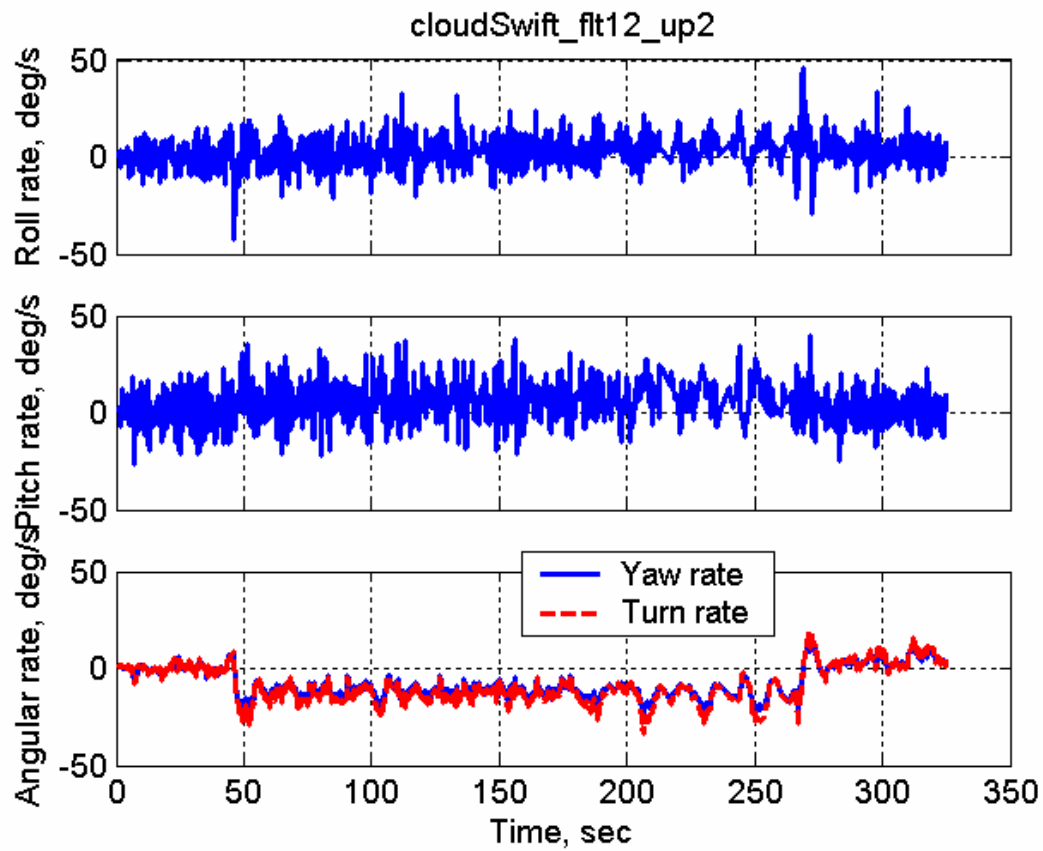
Flight 12, updraft 2

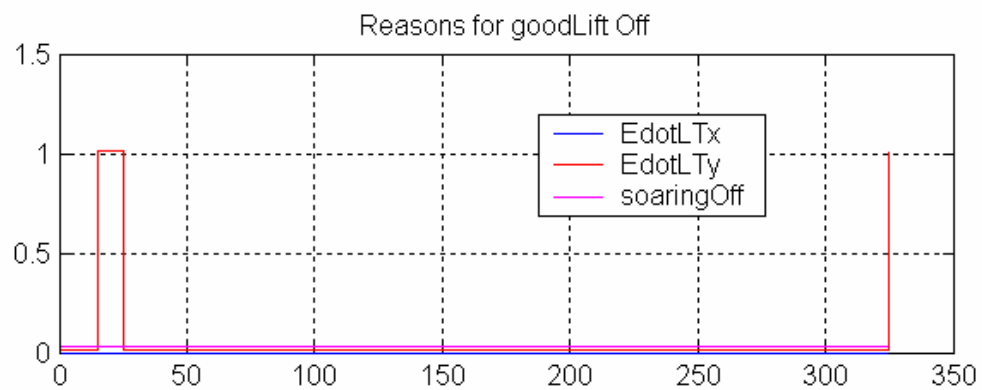
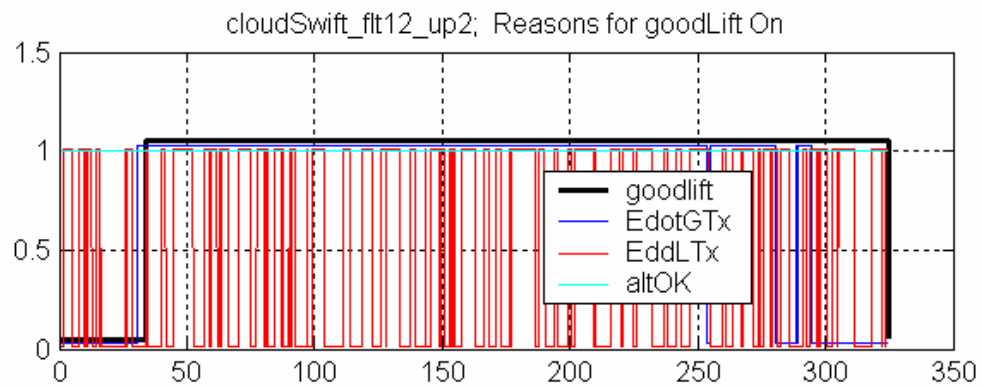
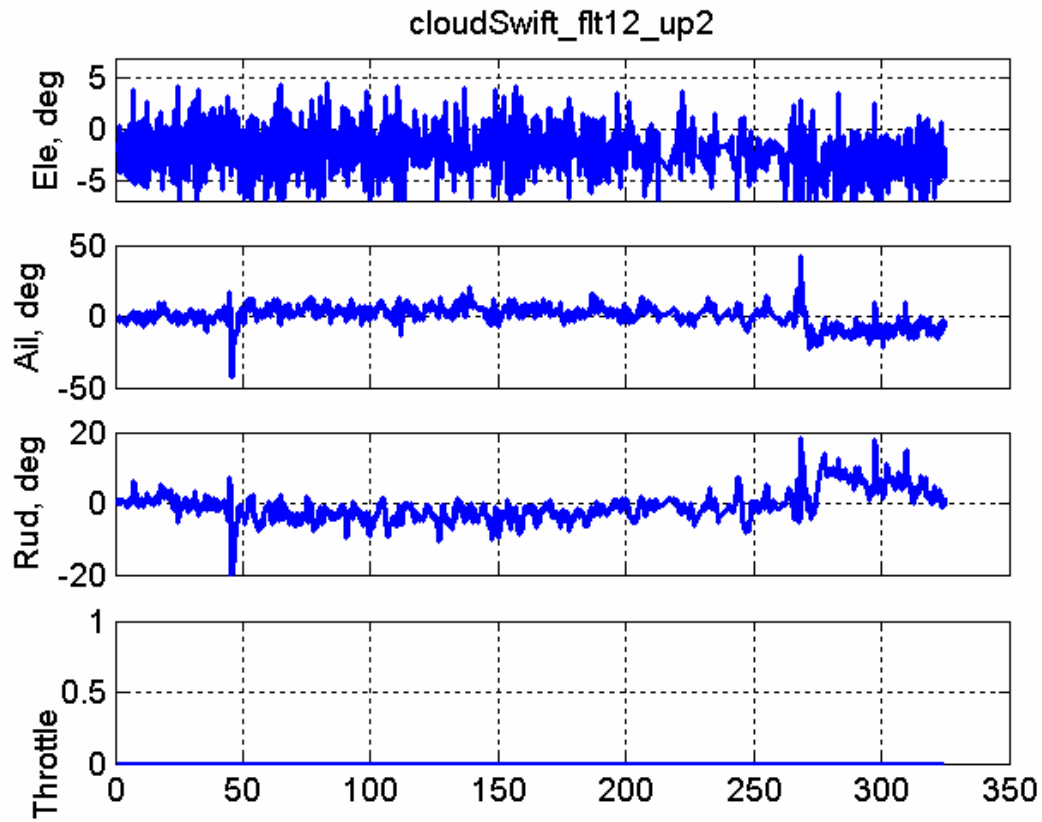
Boomer. Flight path brings a/c back into lift at end. Good centering.

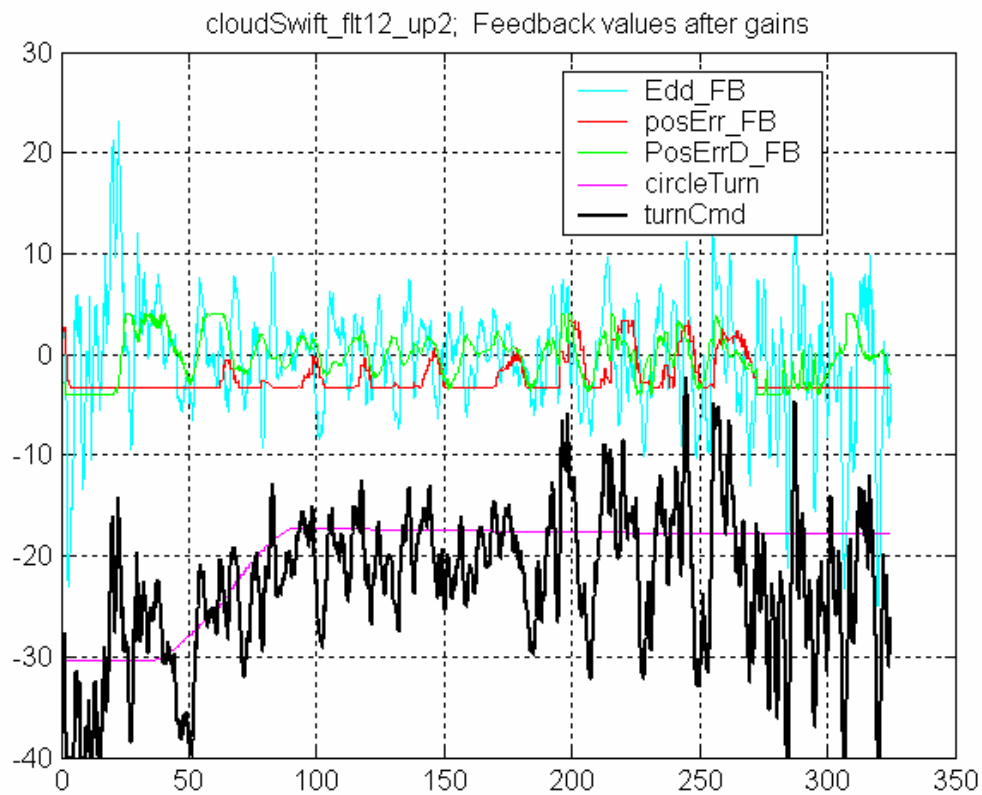
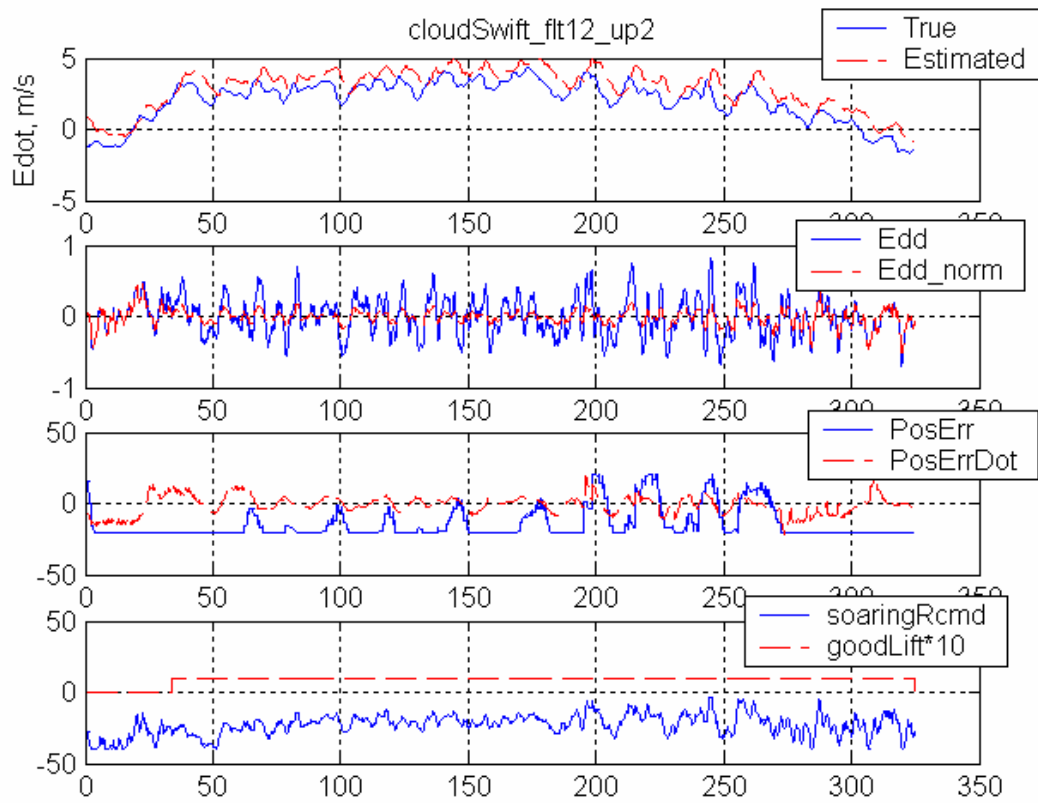






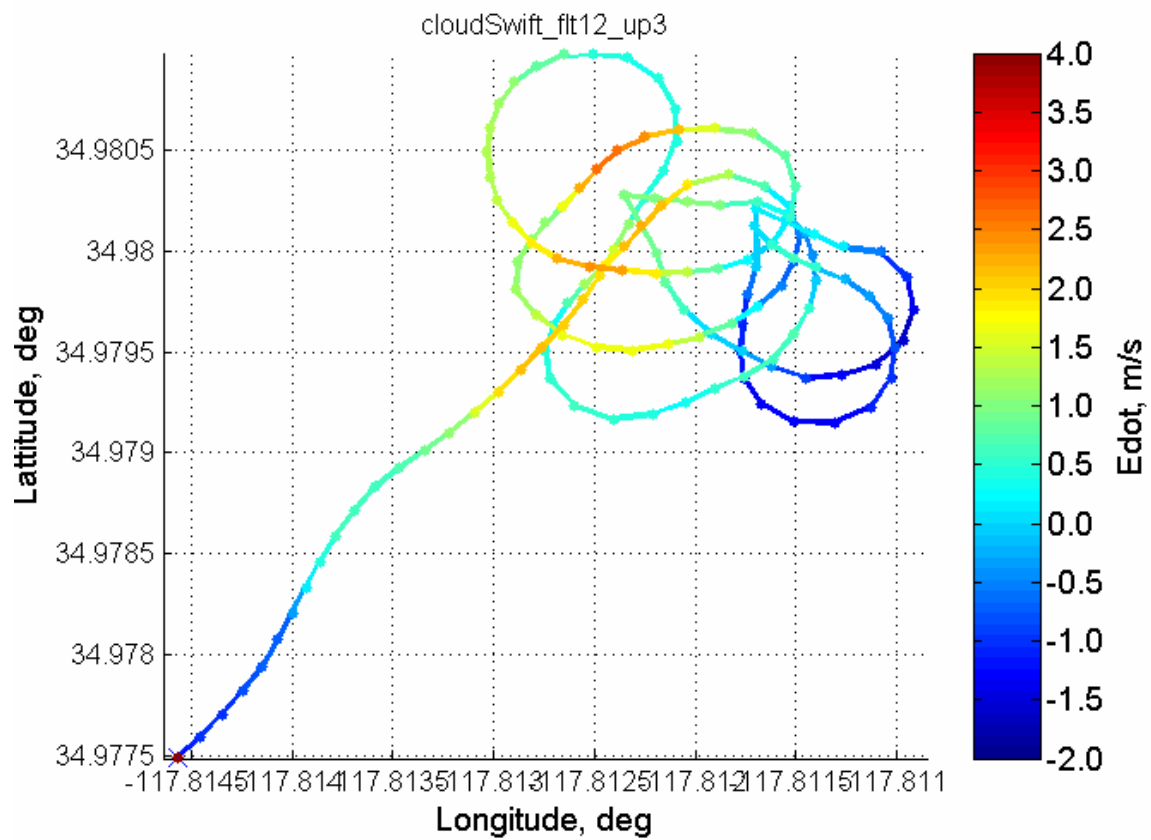


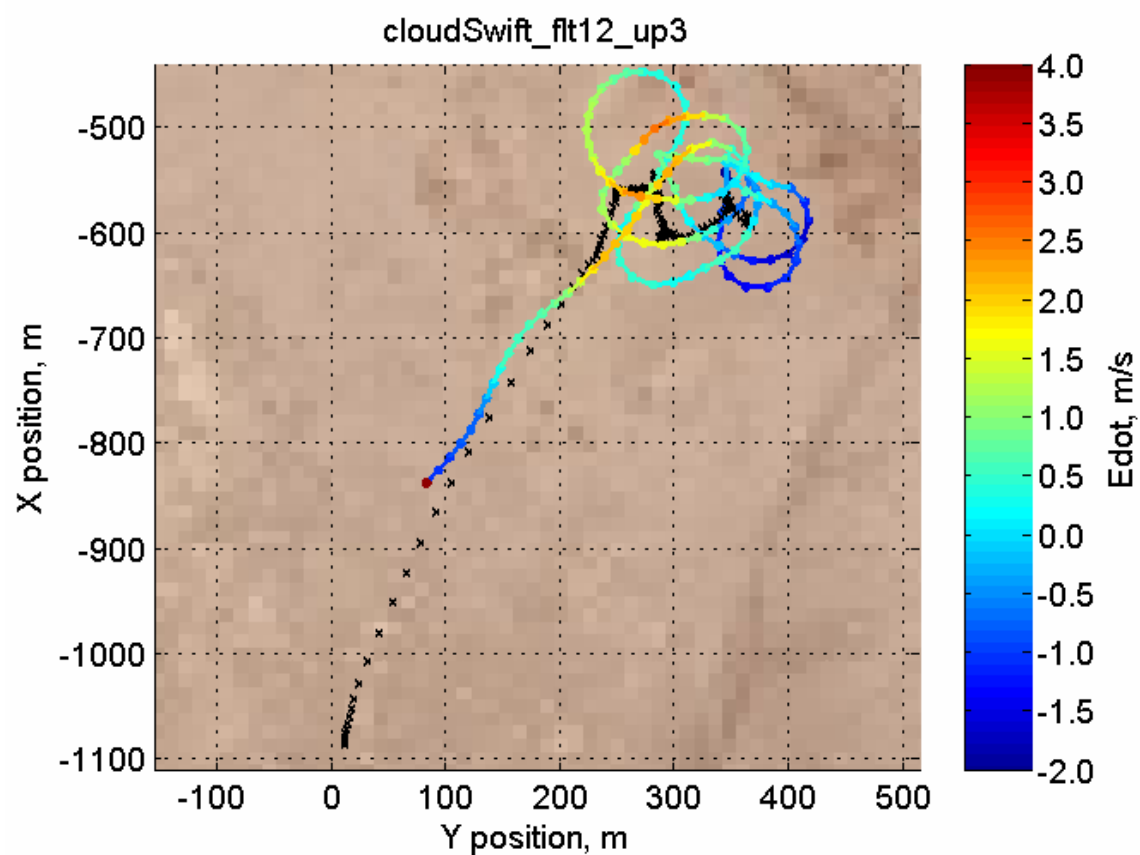
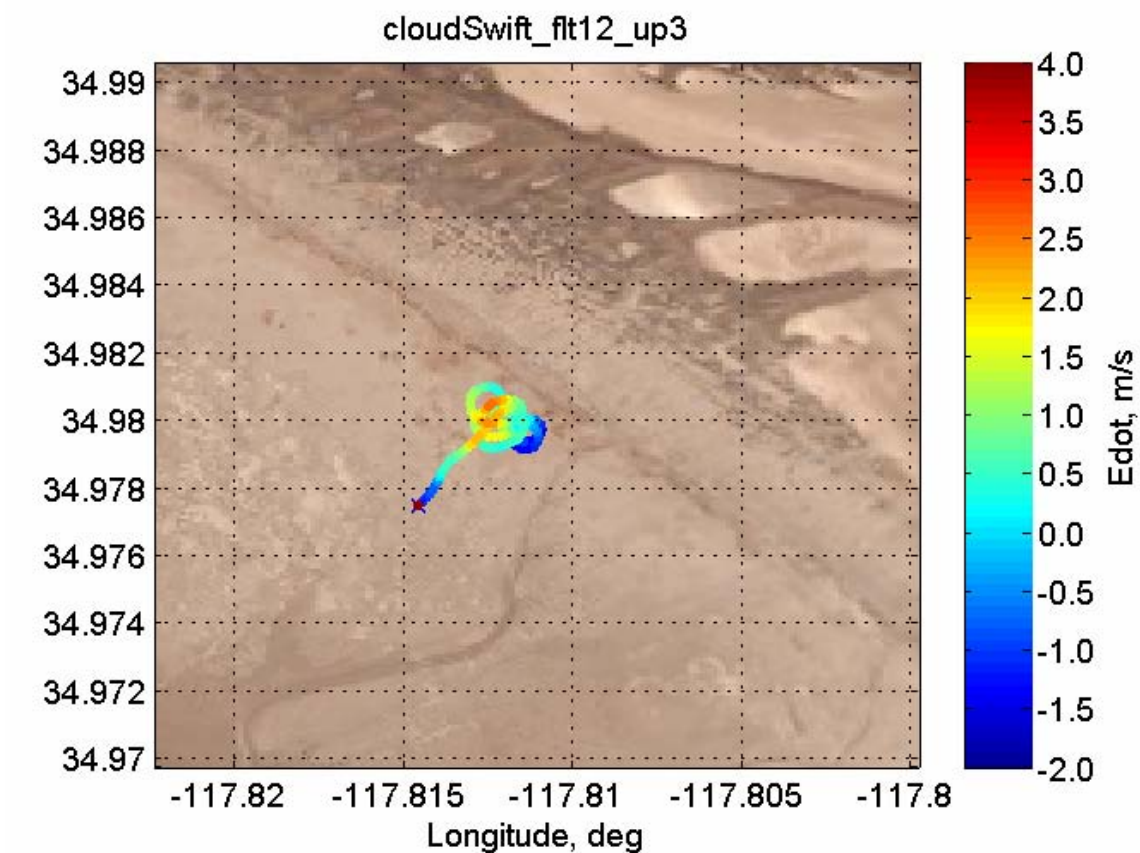


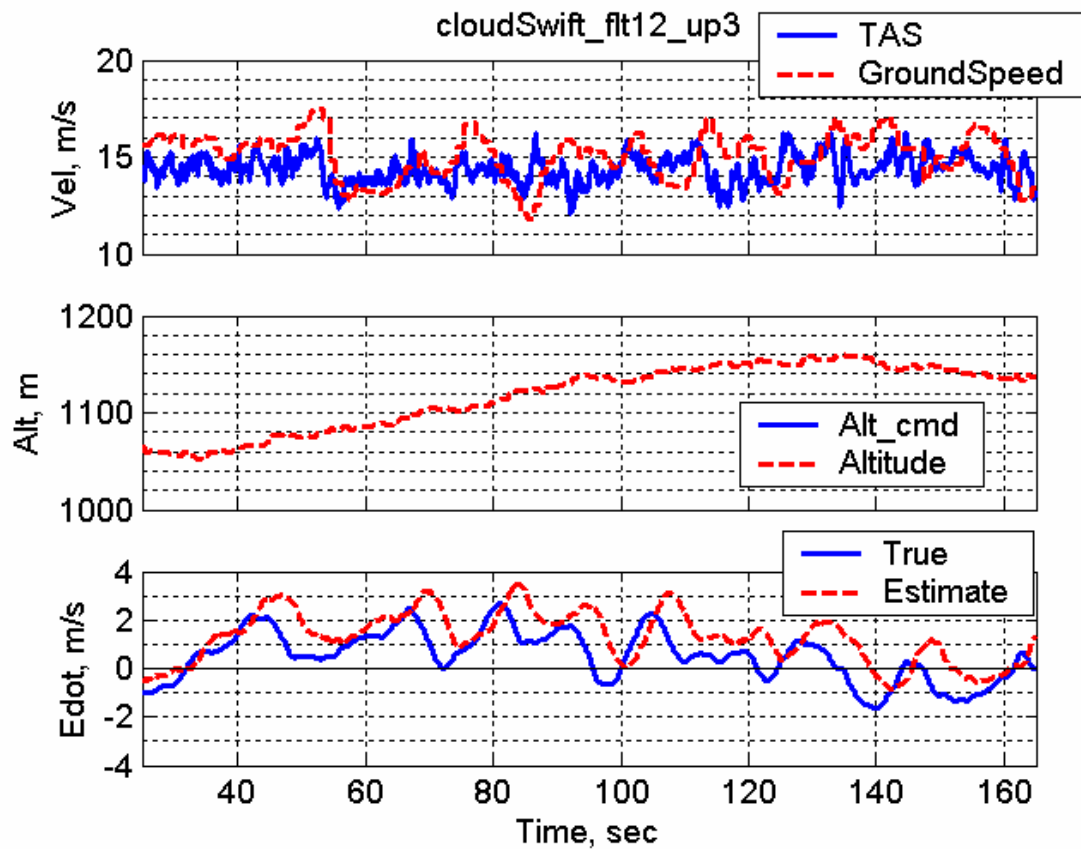
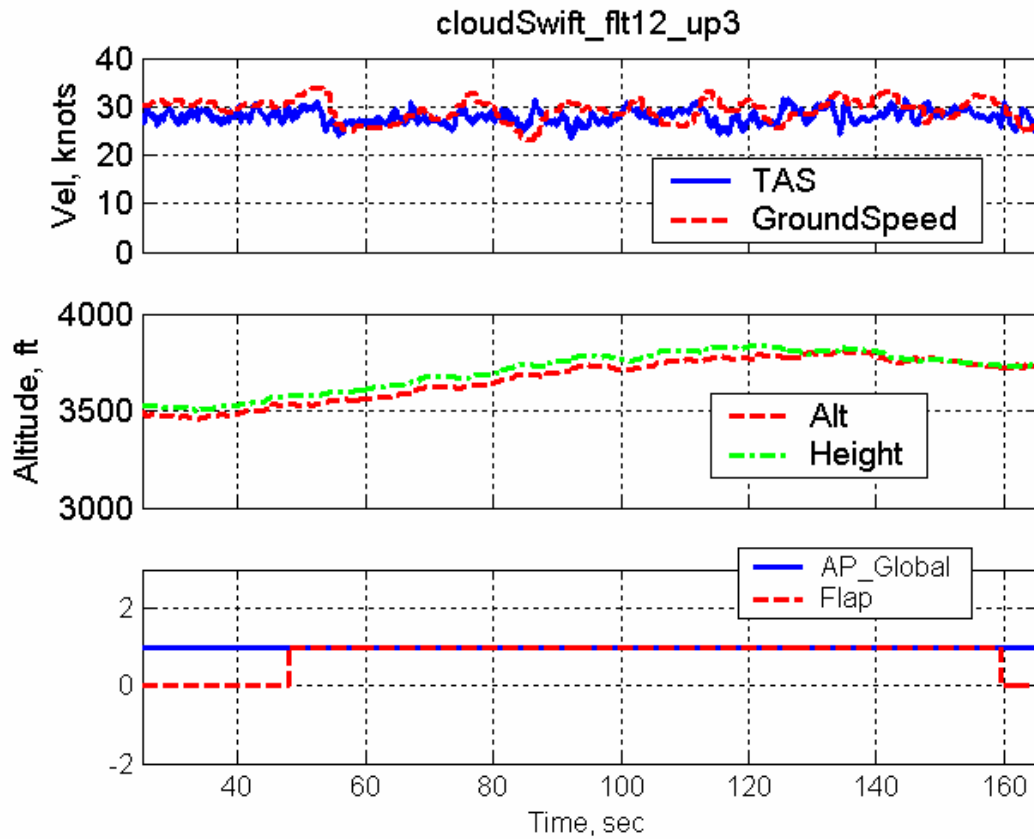


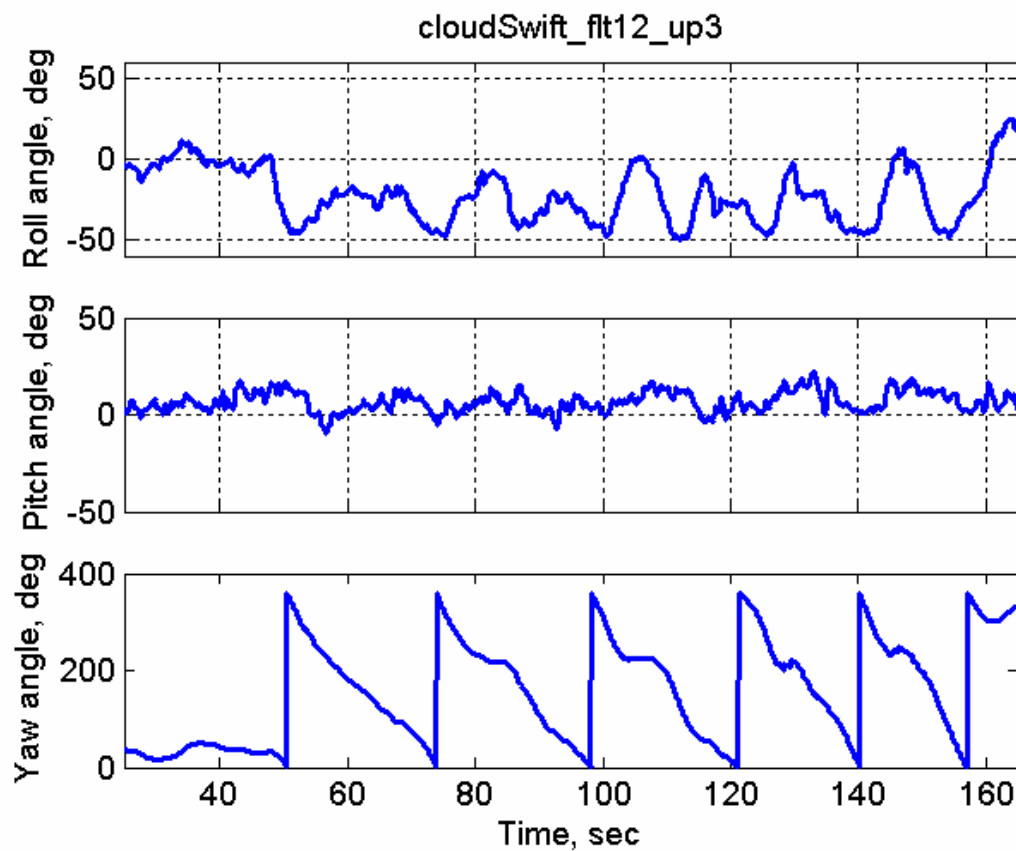
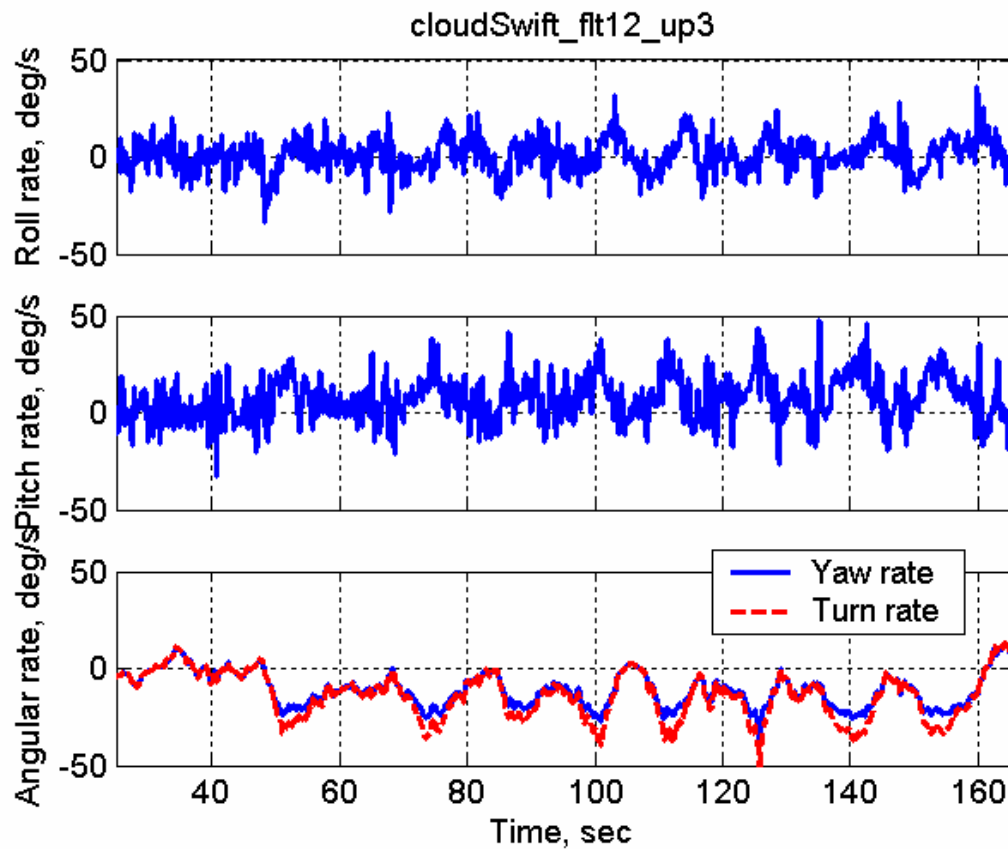
Flight 12, updraft 3

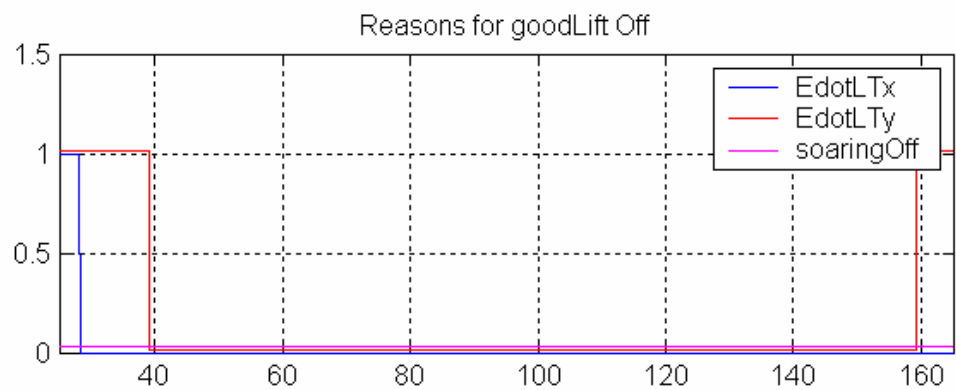
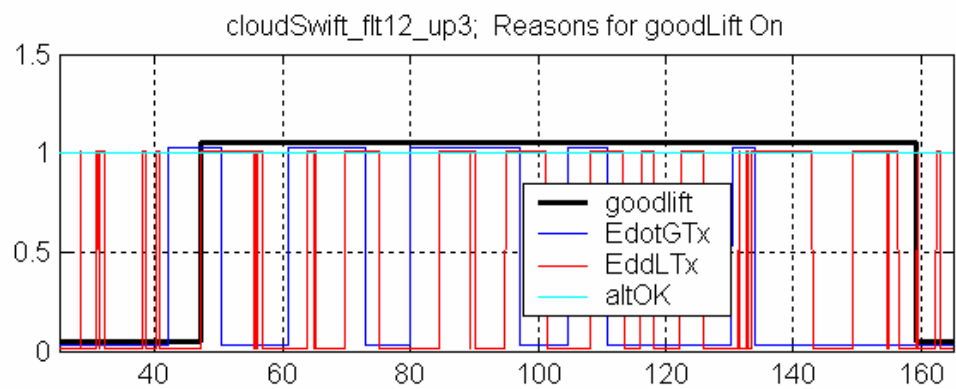
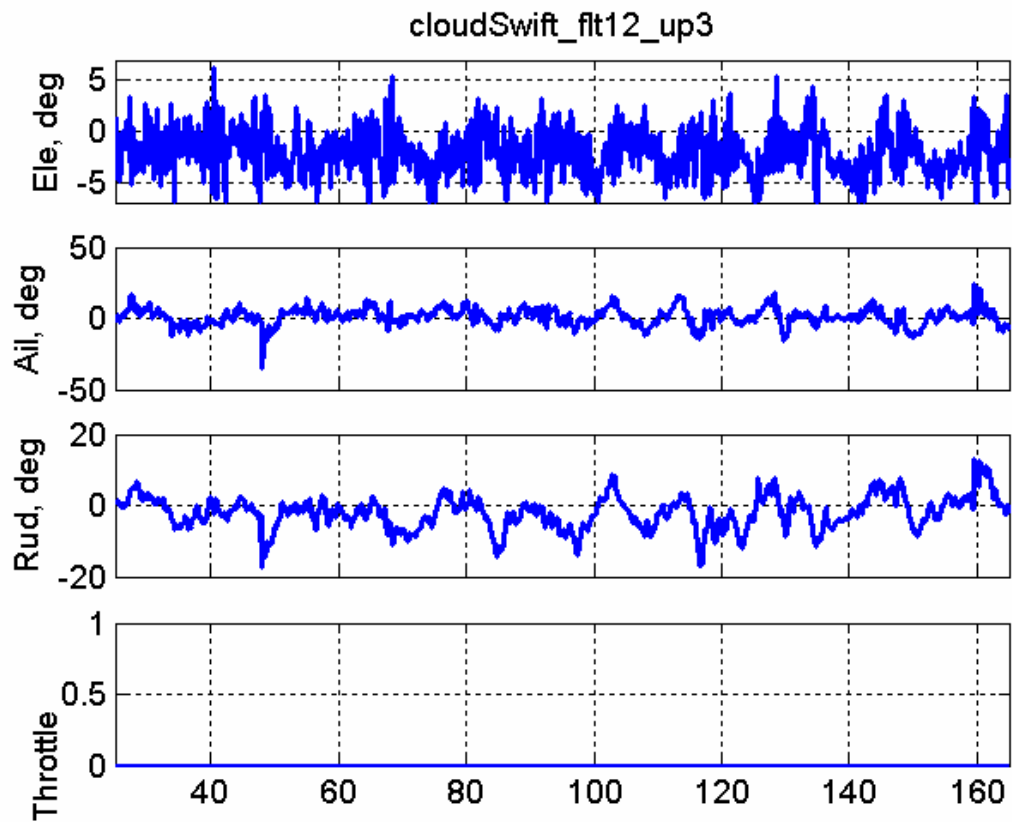
Smaller. Never quite centers it. GPS problems.

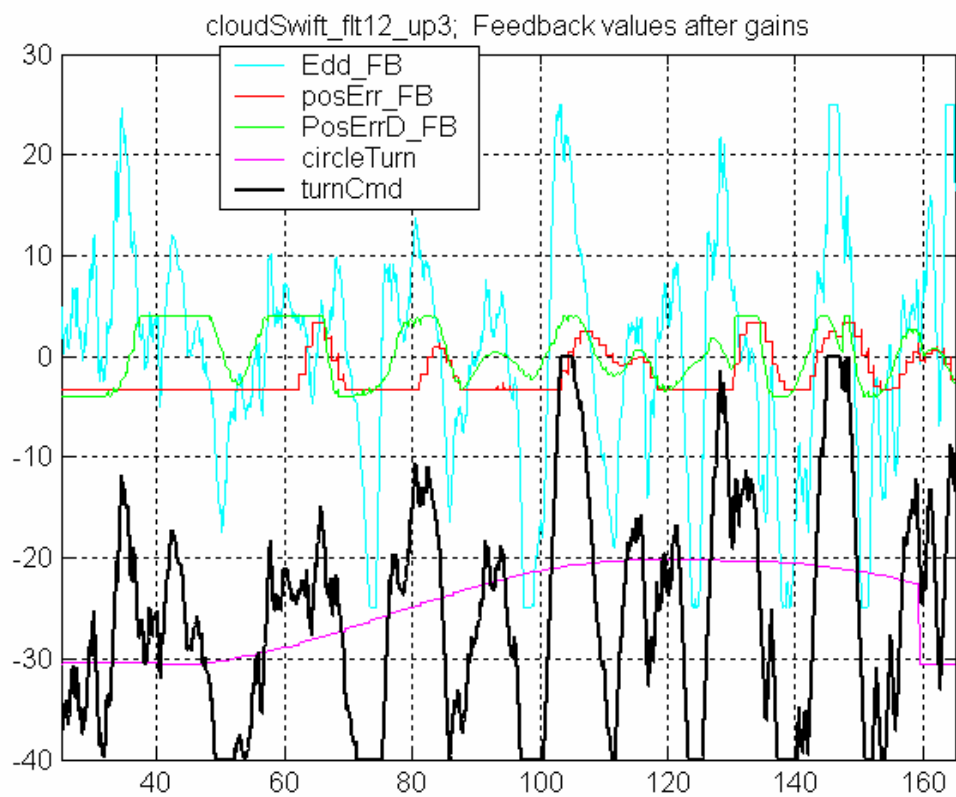
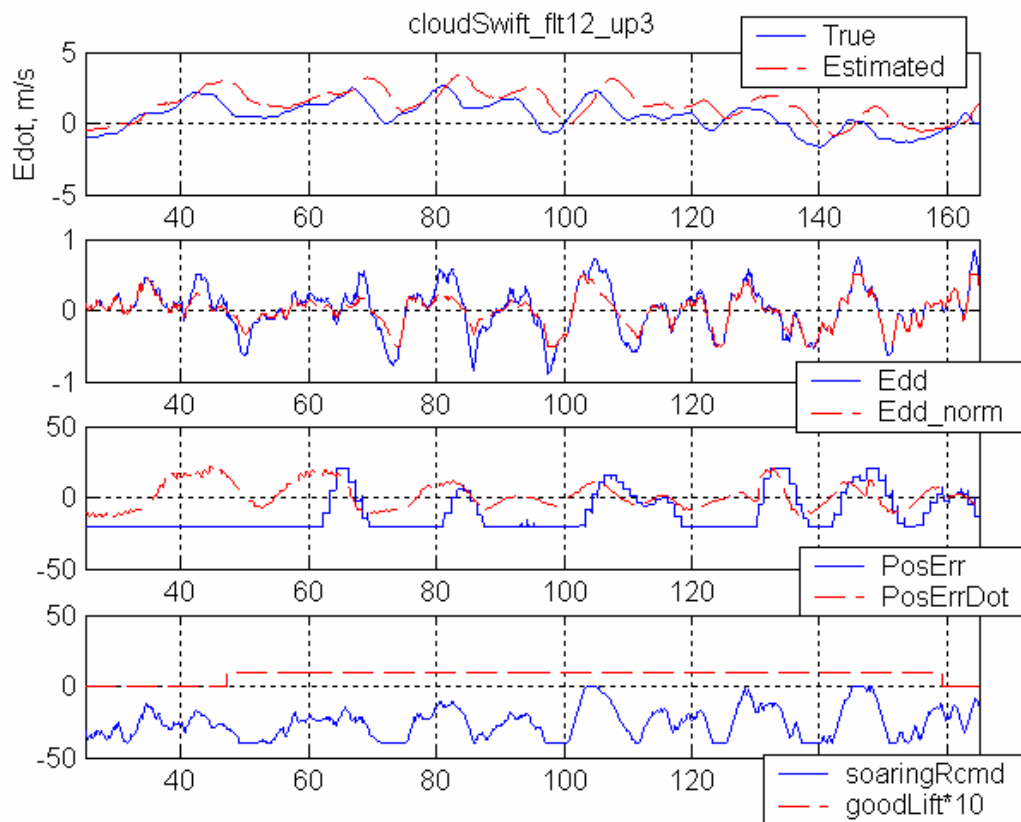






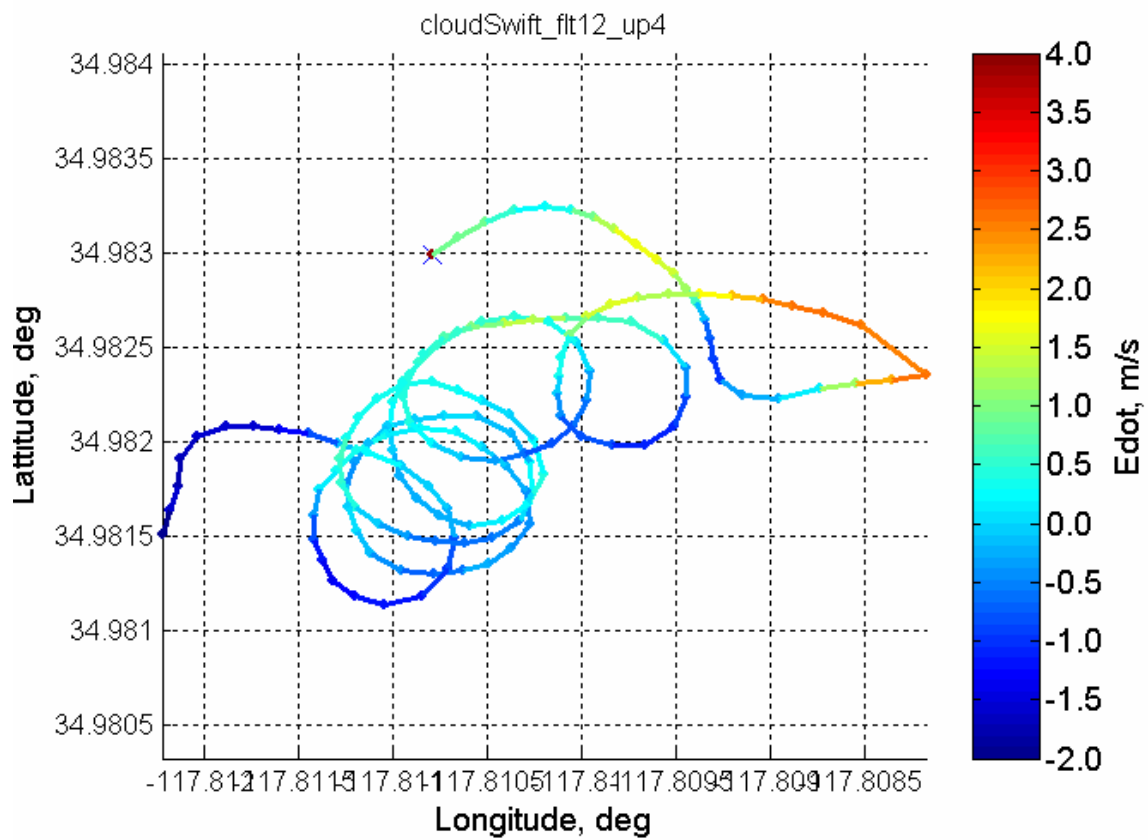


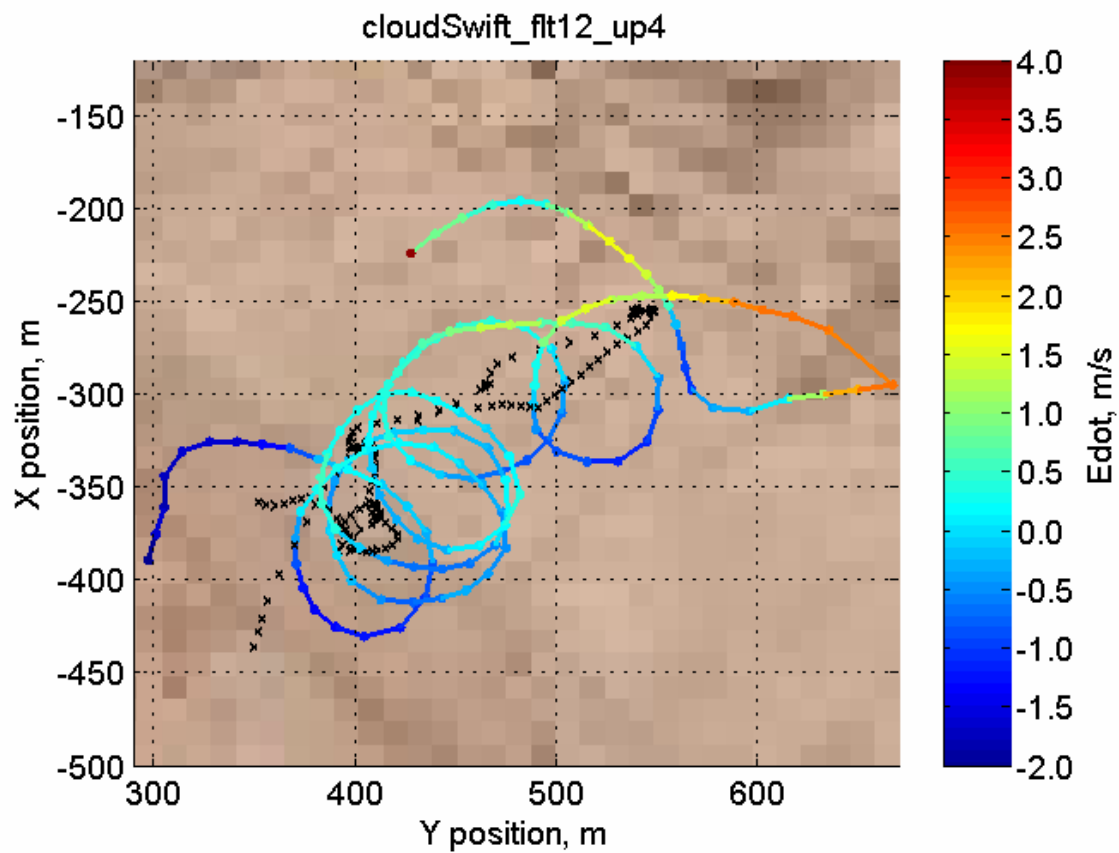
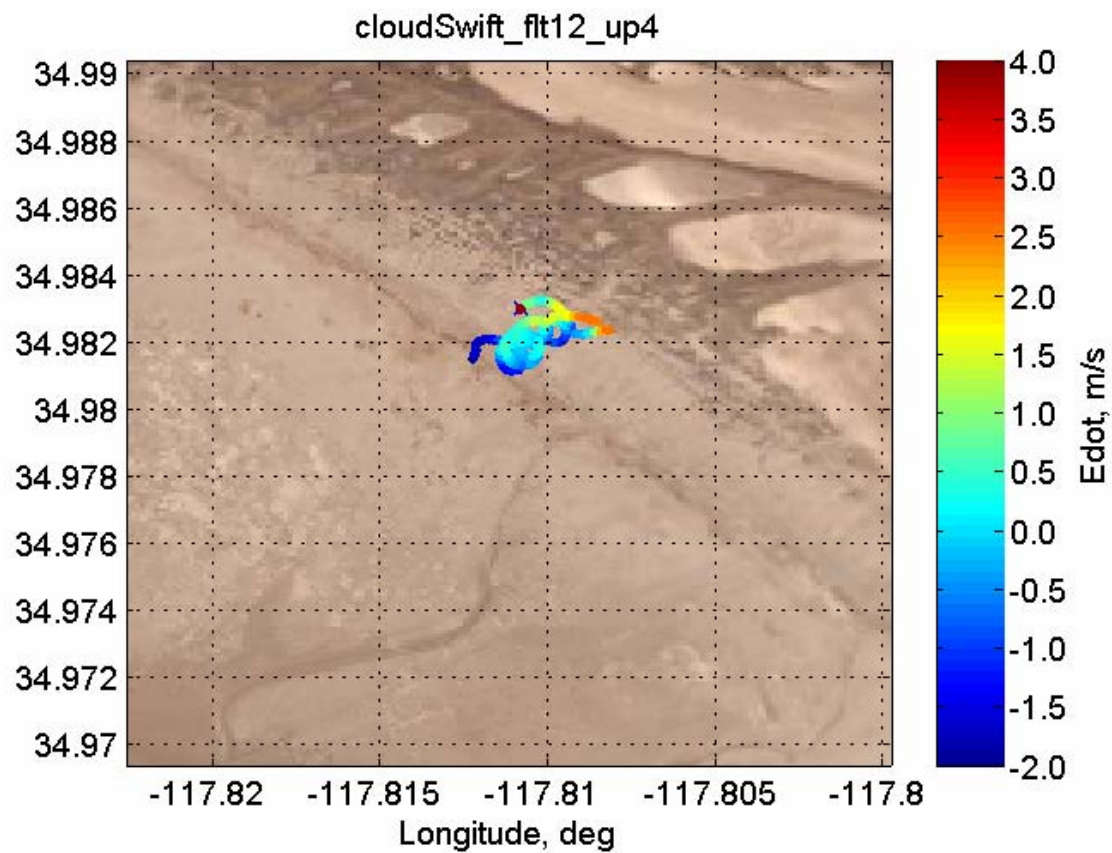


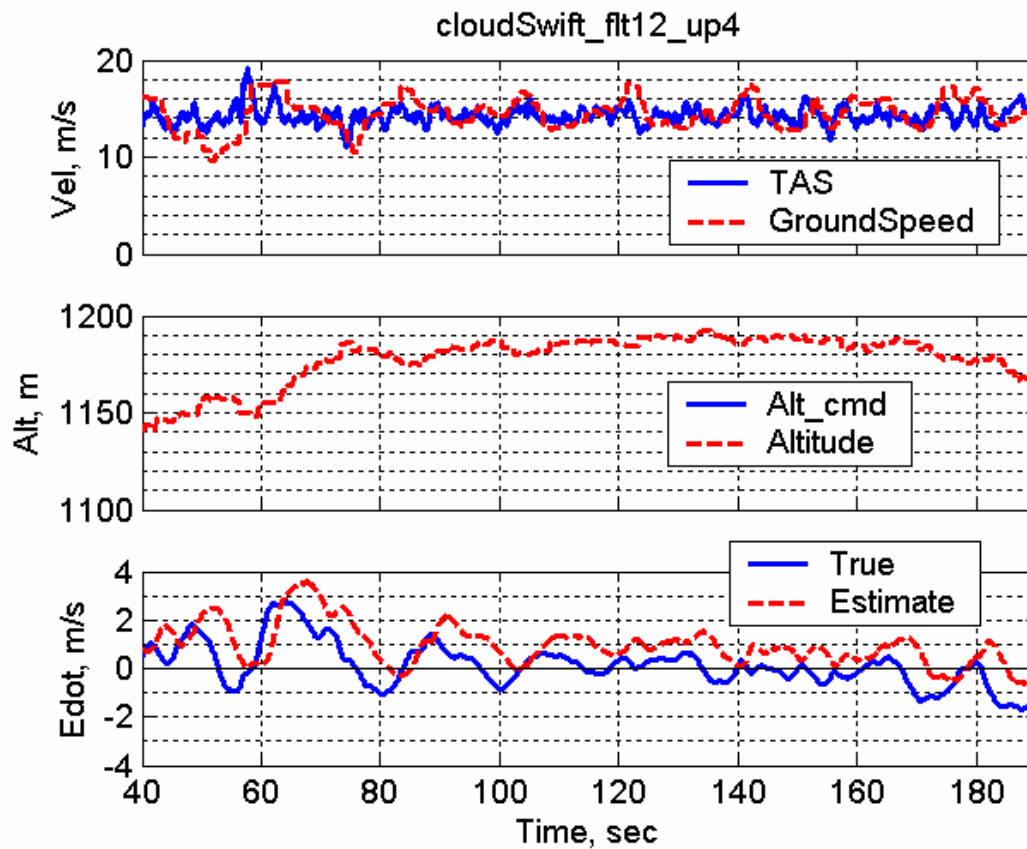
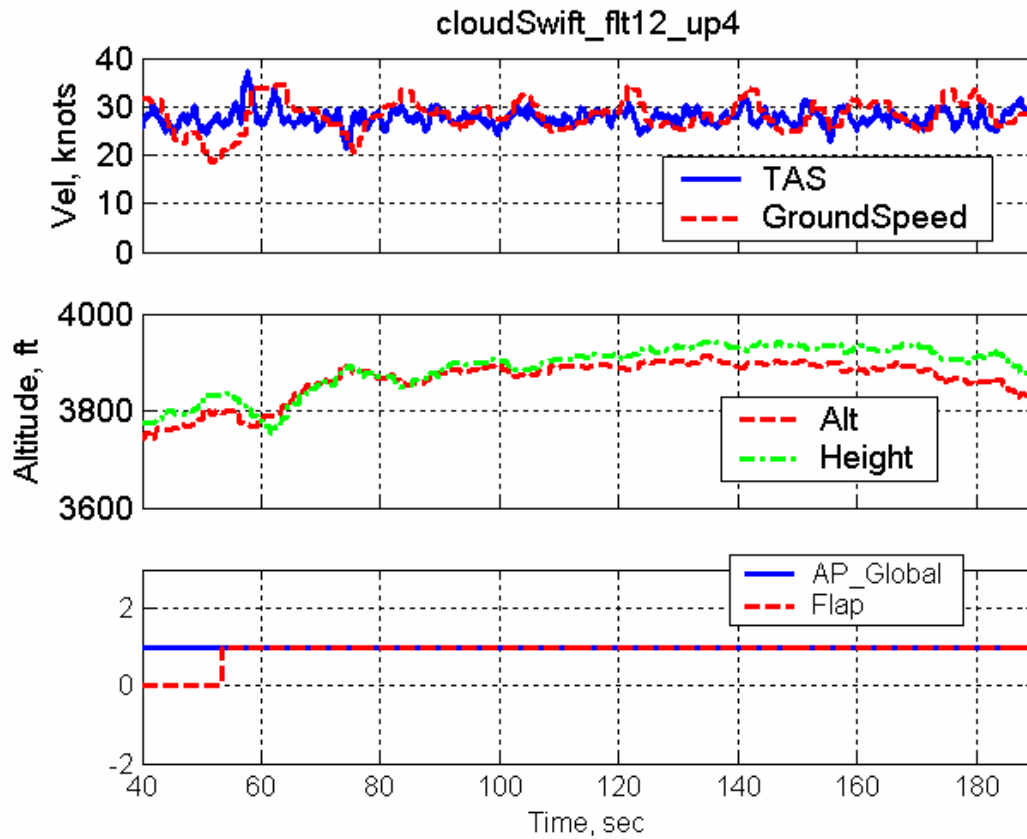


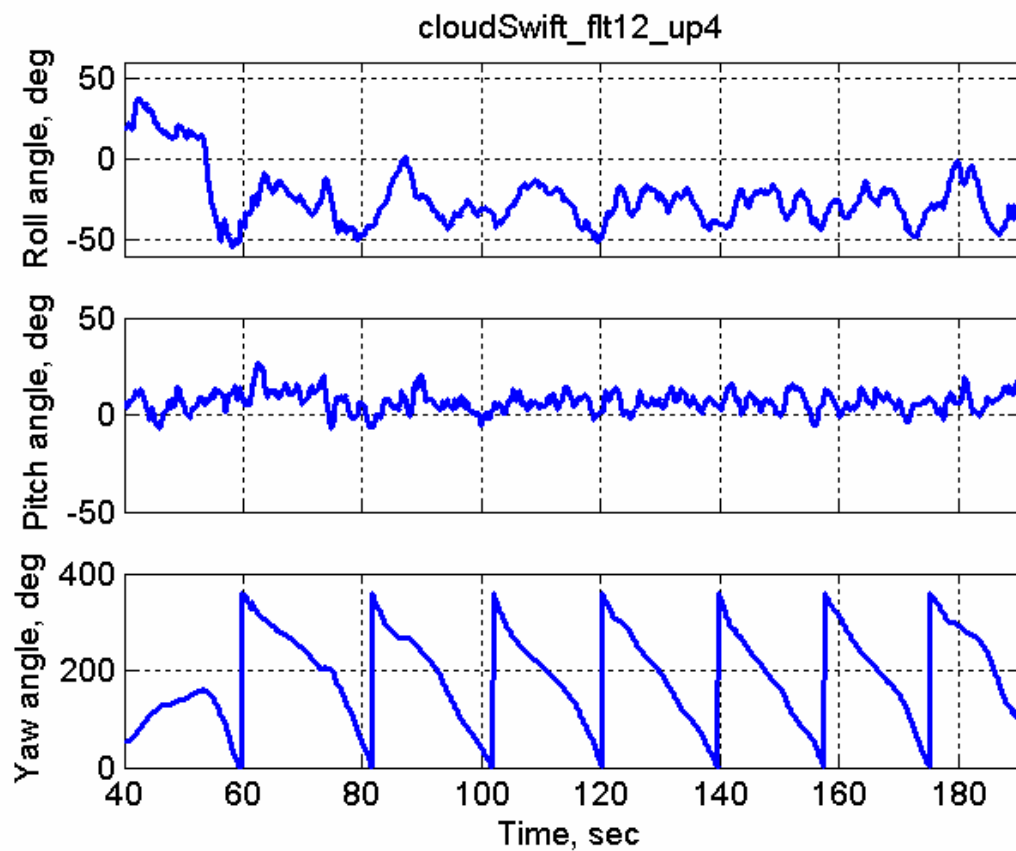
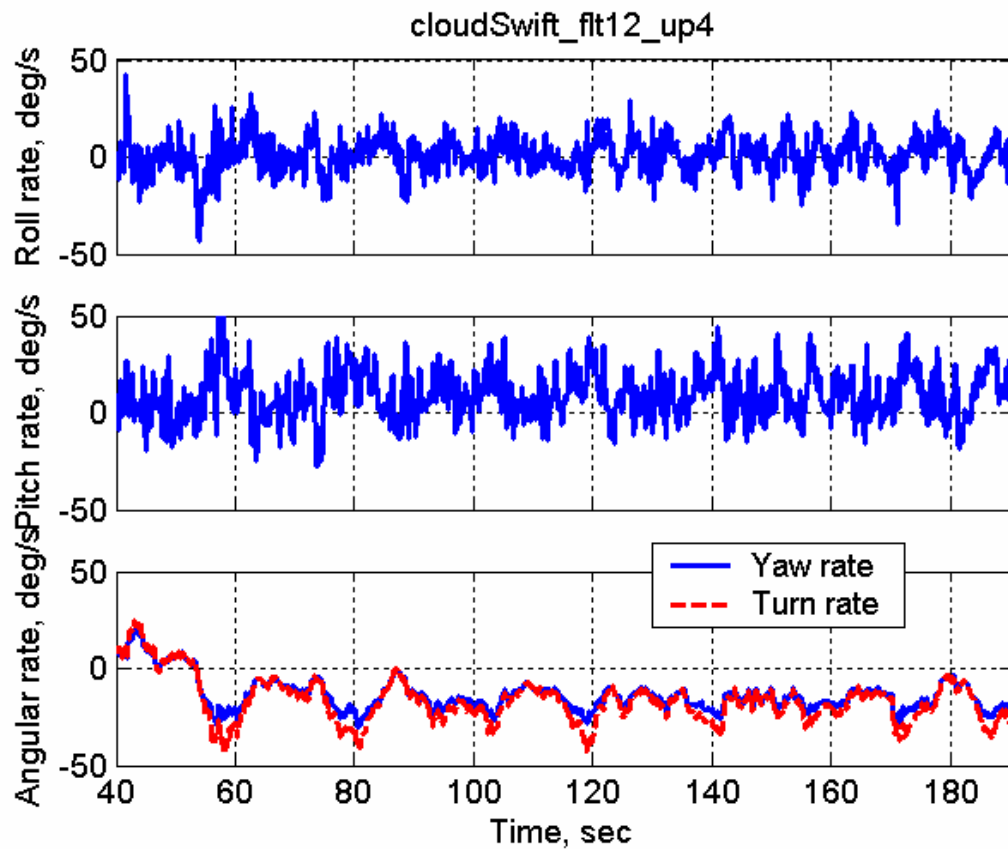
Flight 12, updraft 4

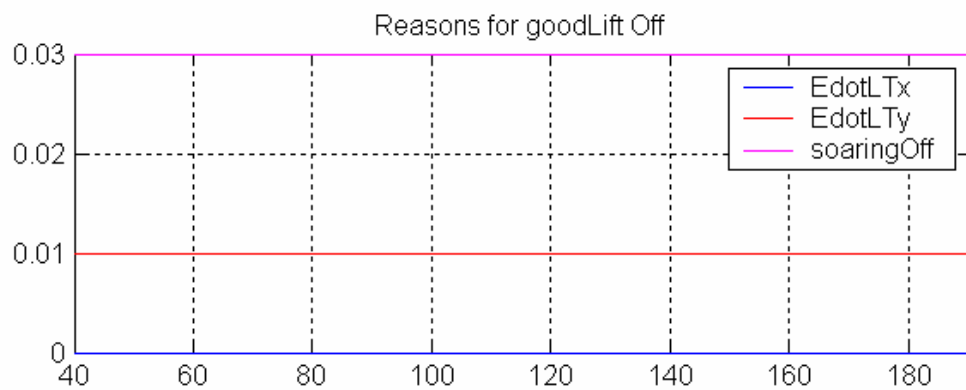
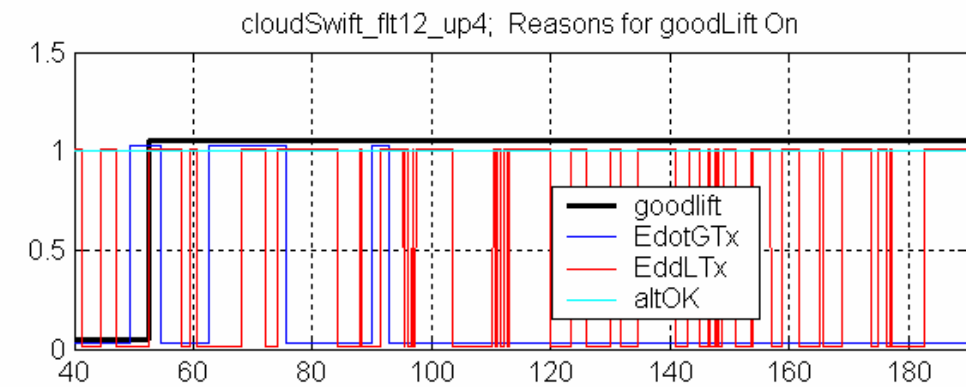
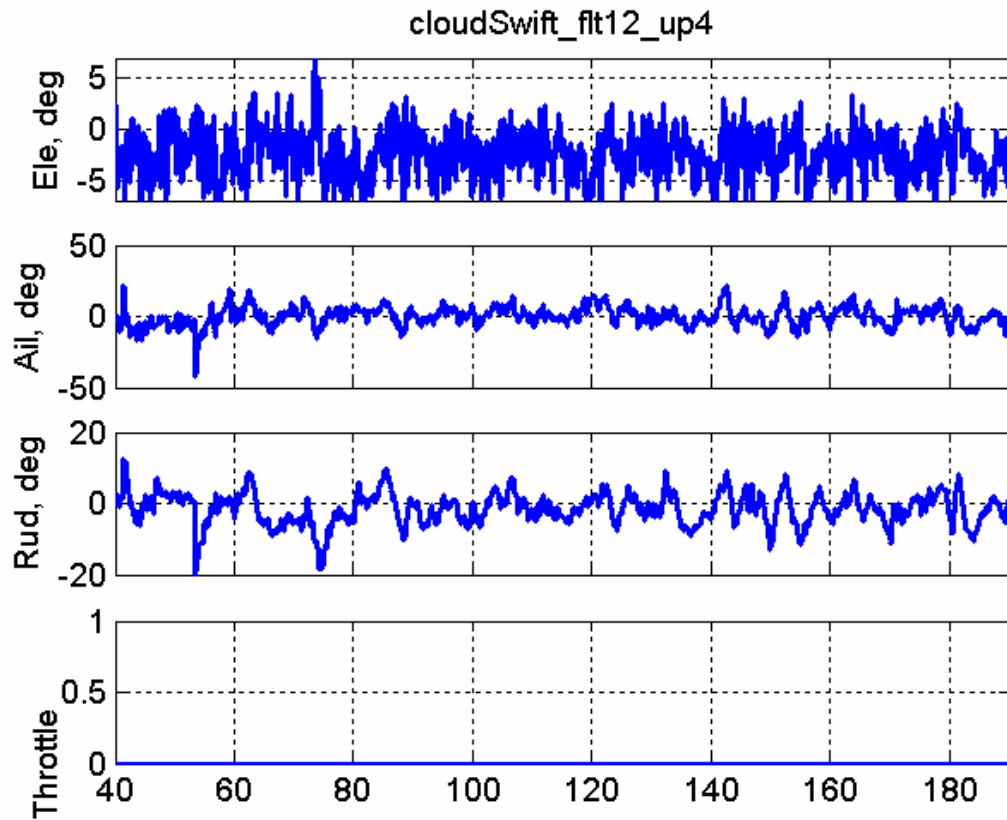
GPS problem caused aircraft to fly out of lift. The aircraft never got back into the good lift.

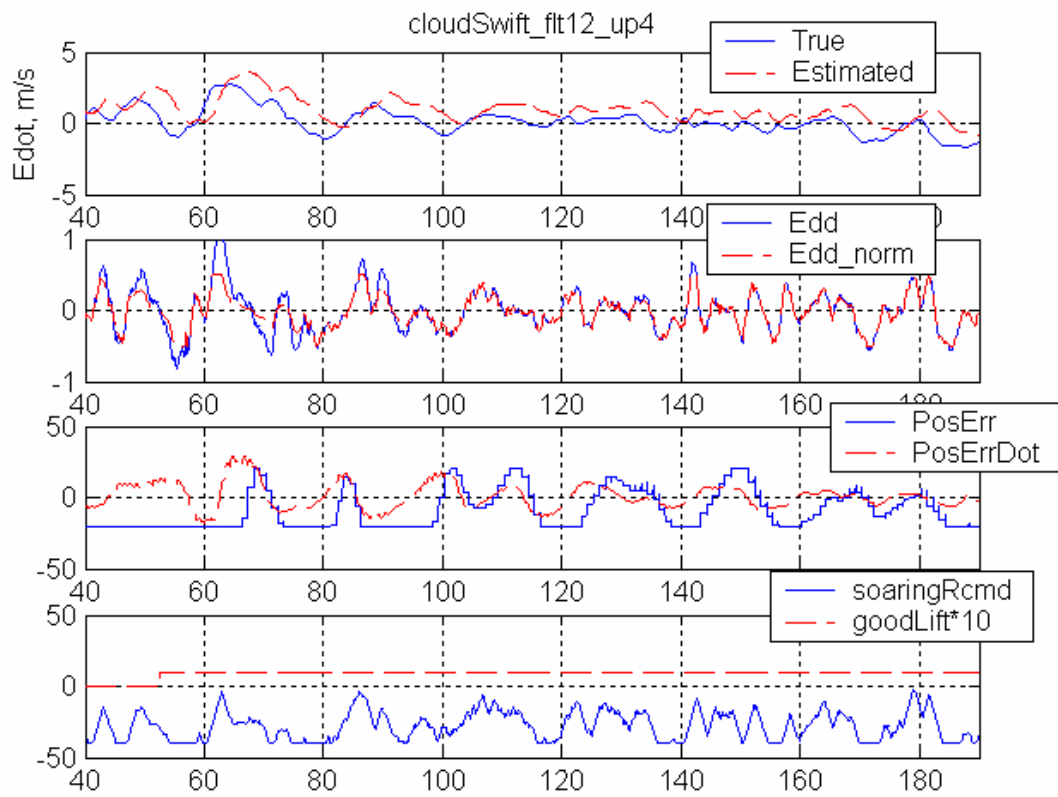






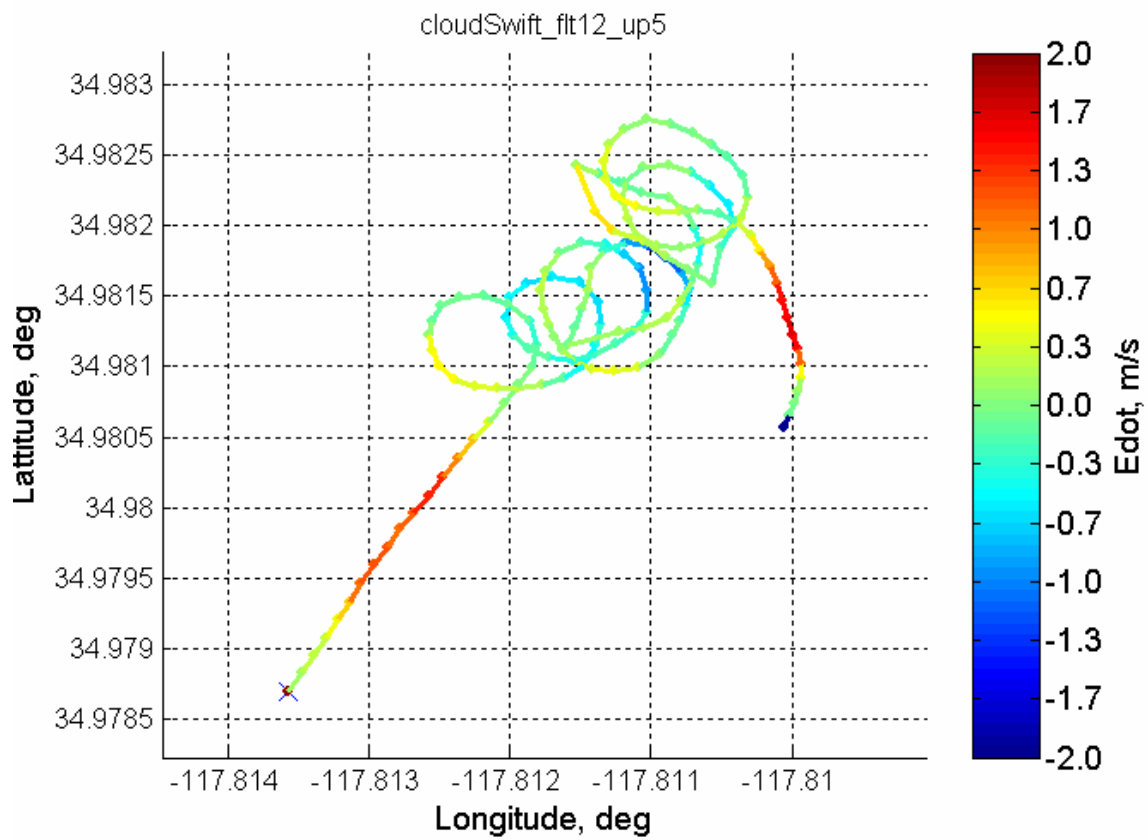


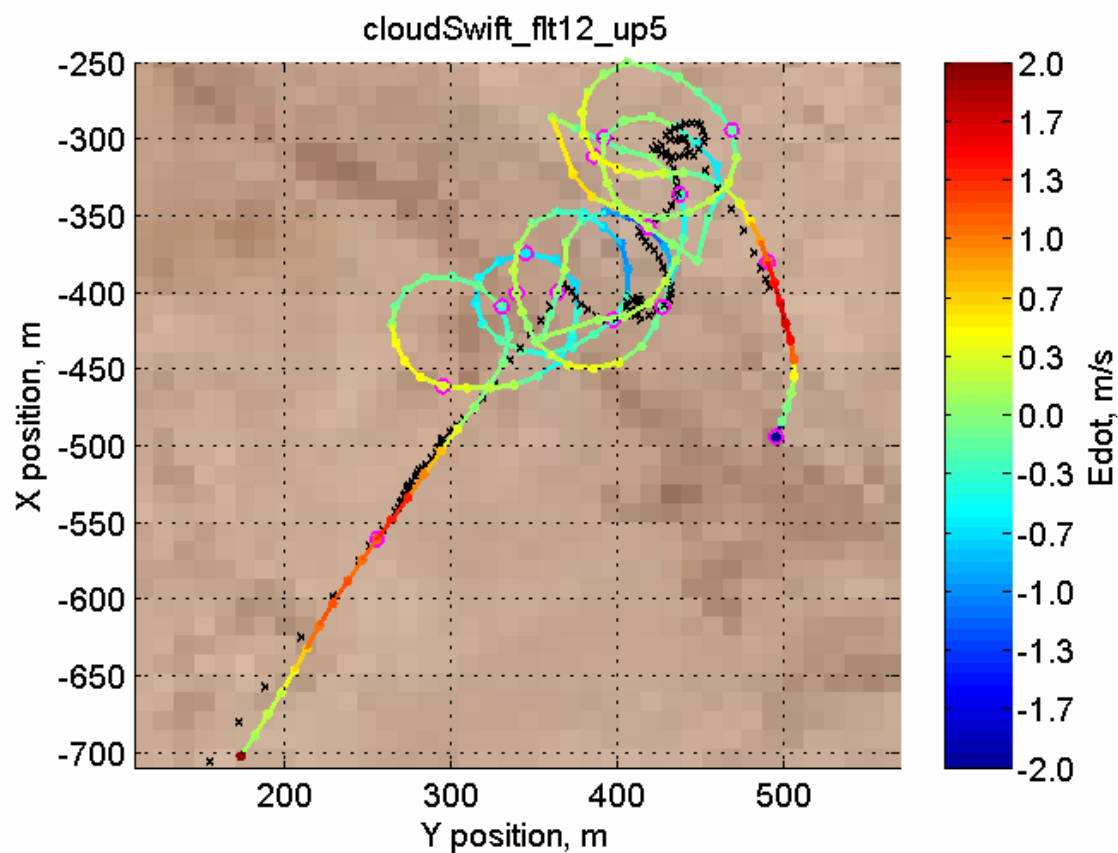
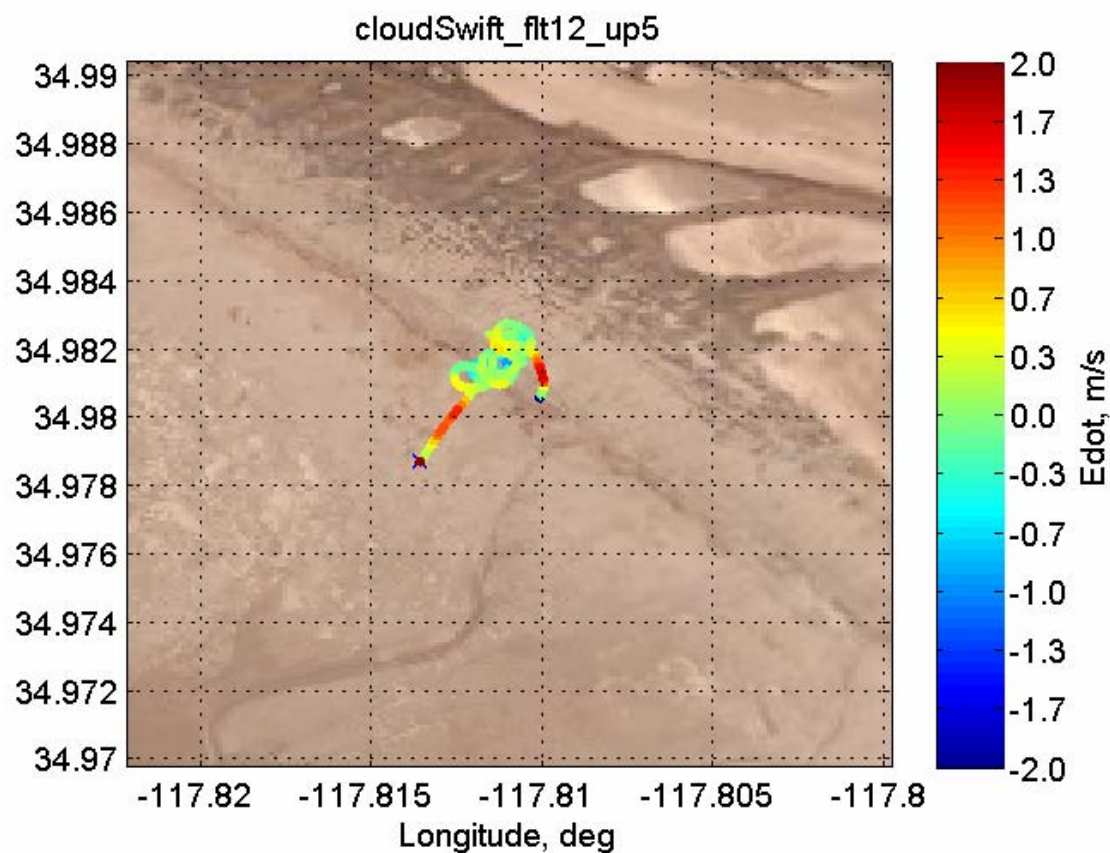


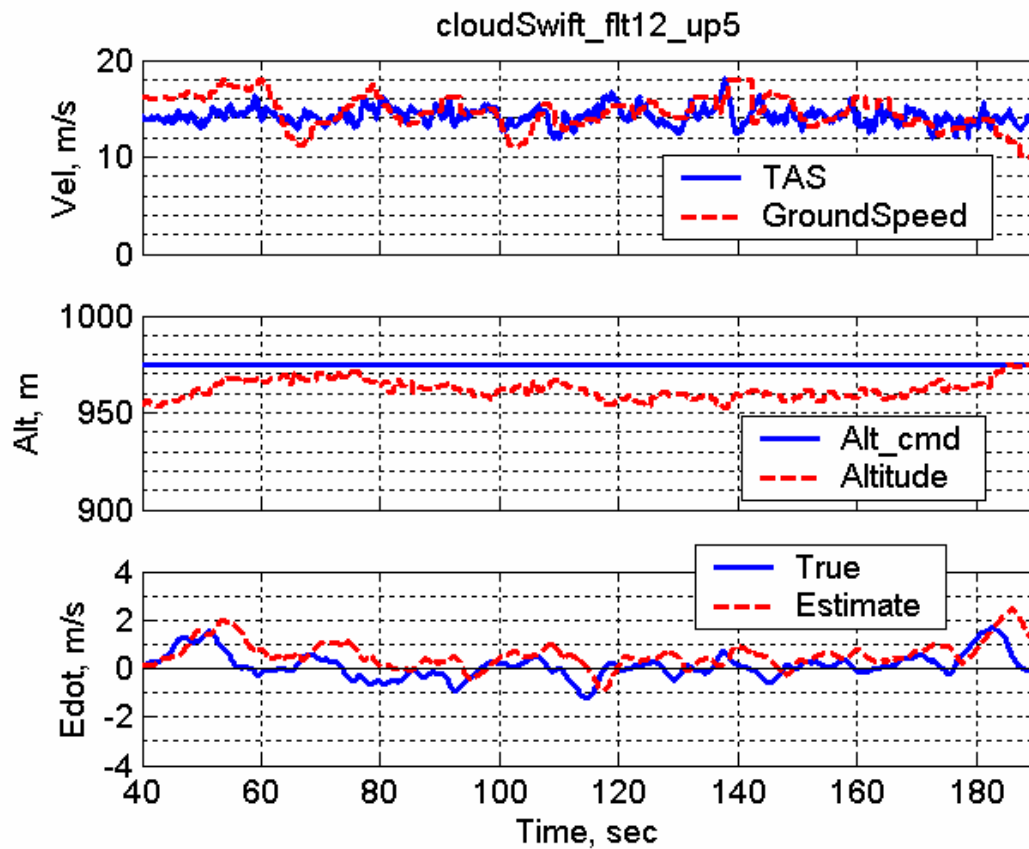
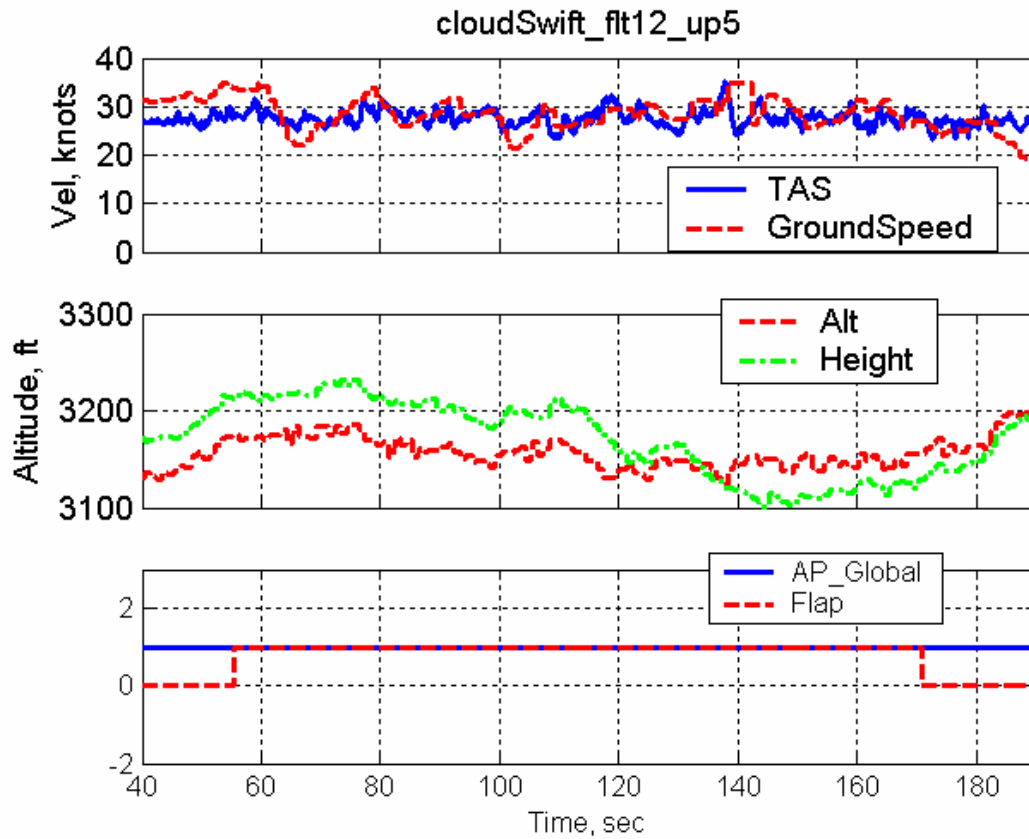


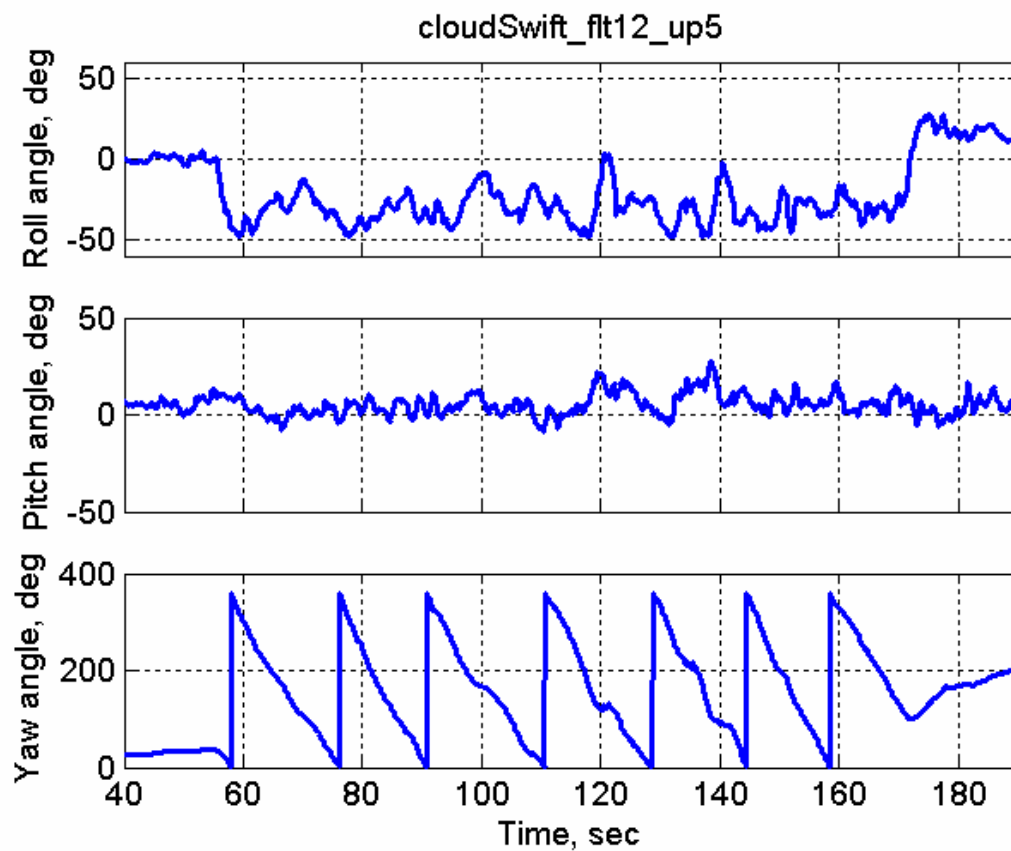
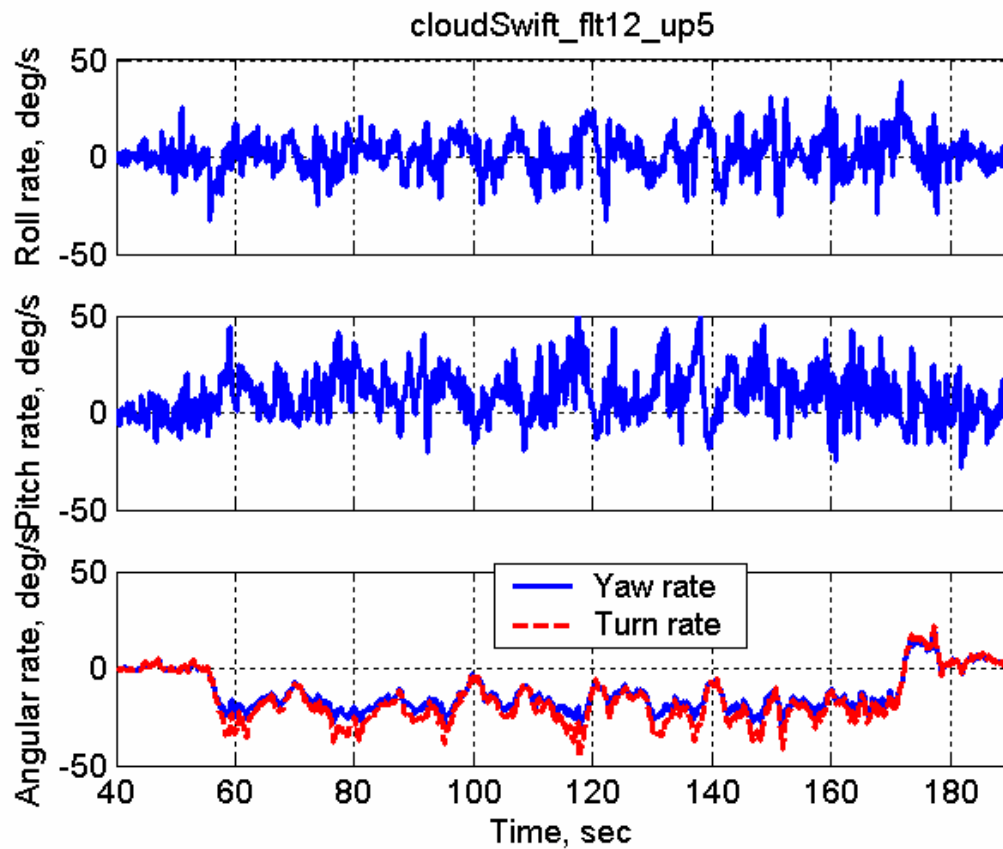
Flight 12, updraft 5

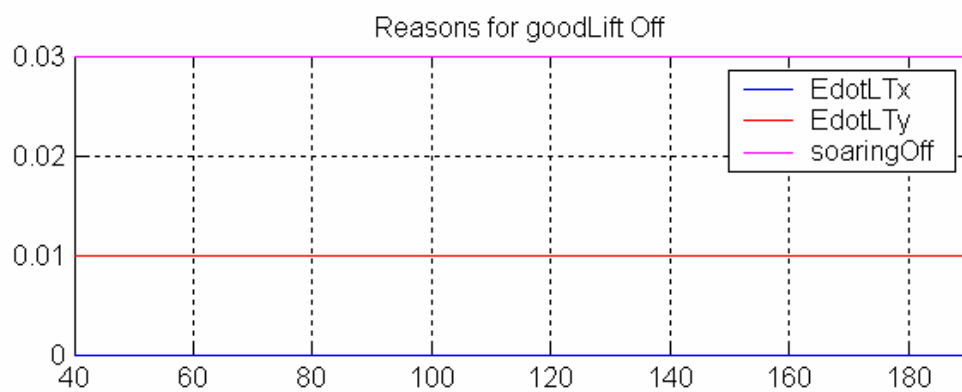
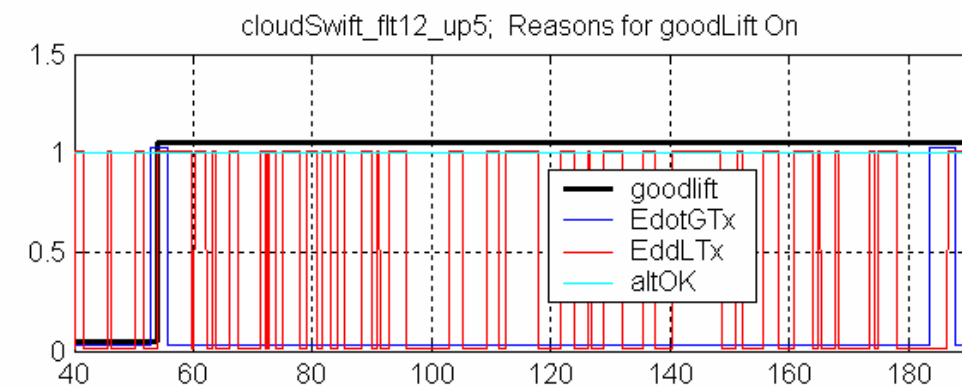
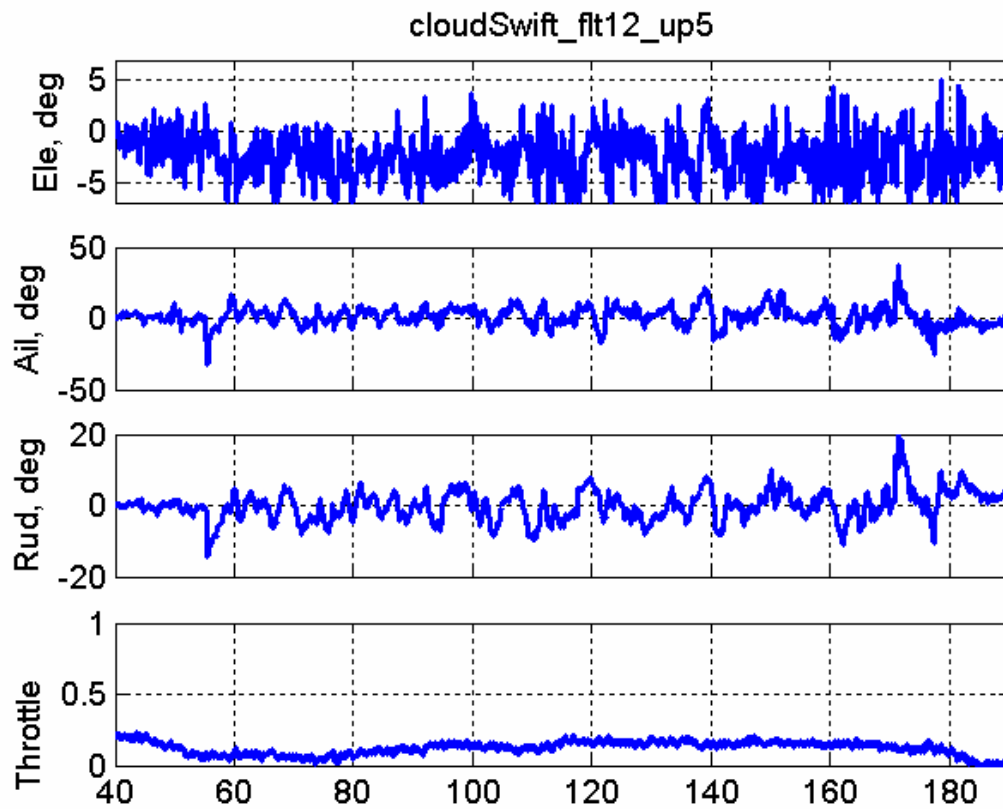
Seems to totally miss the lift. Flies through it at end. posErr saturation makes it worse. posErrD helped.

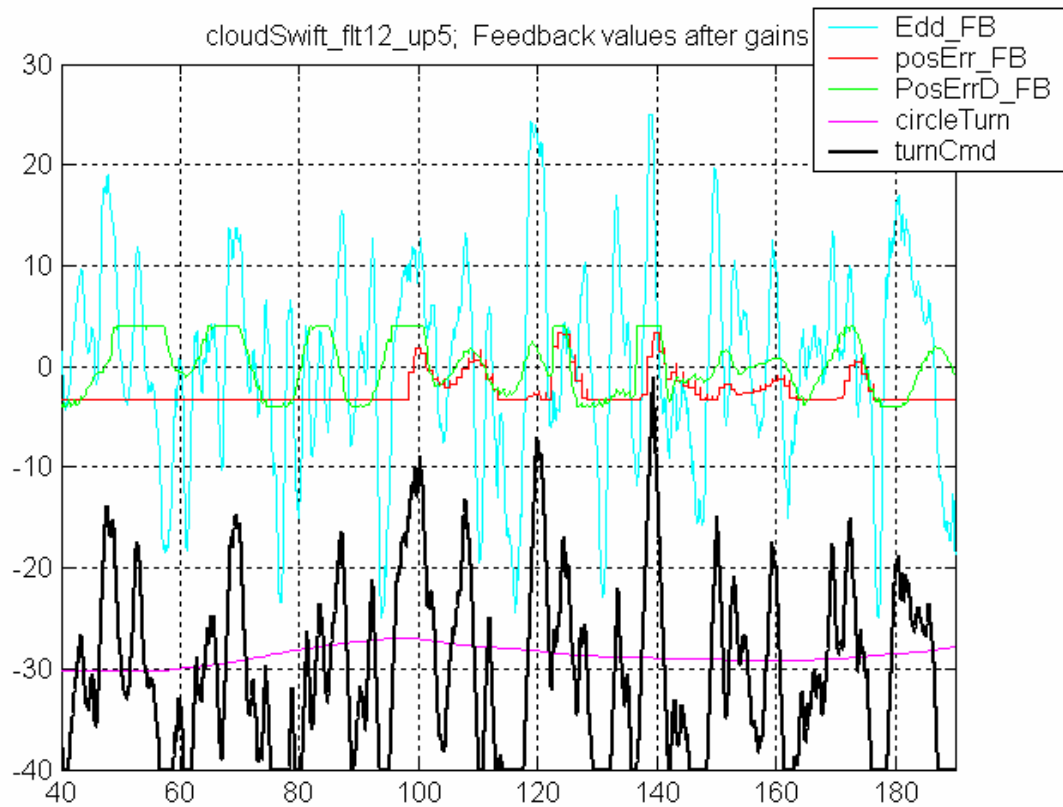
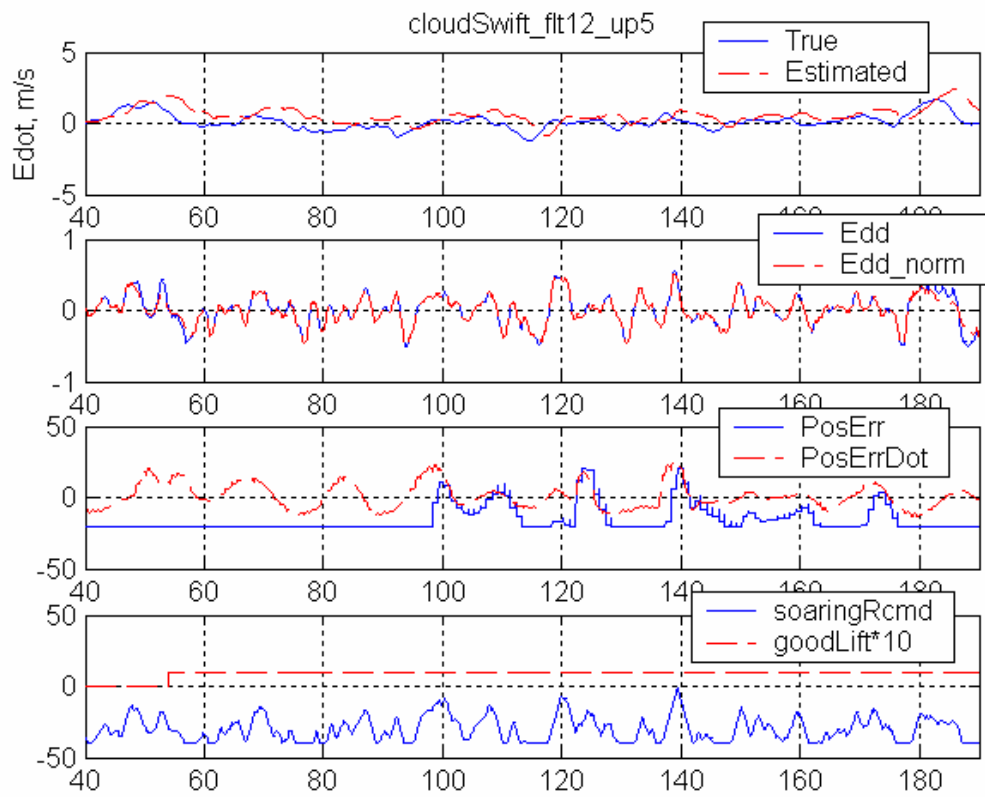






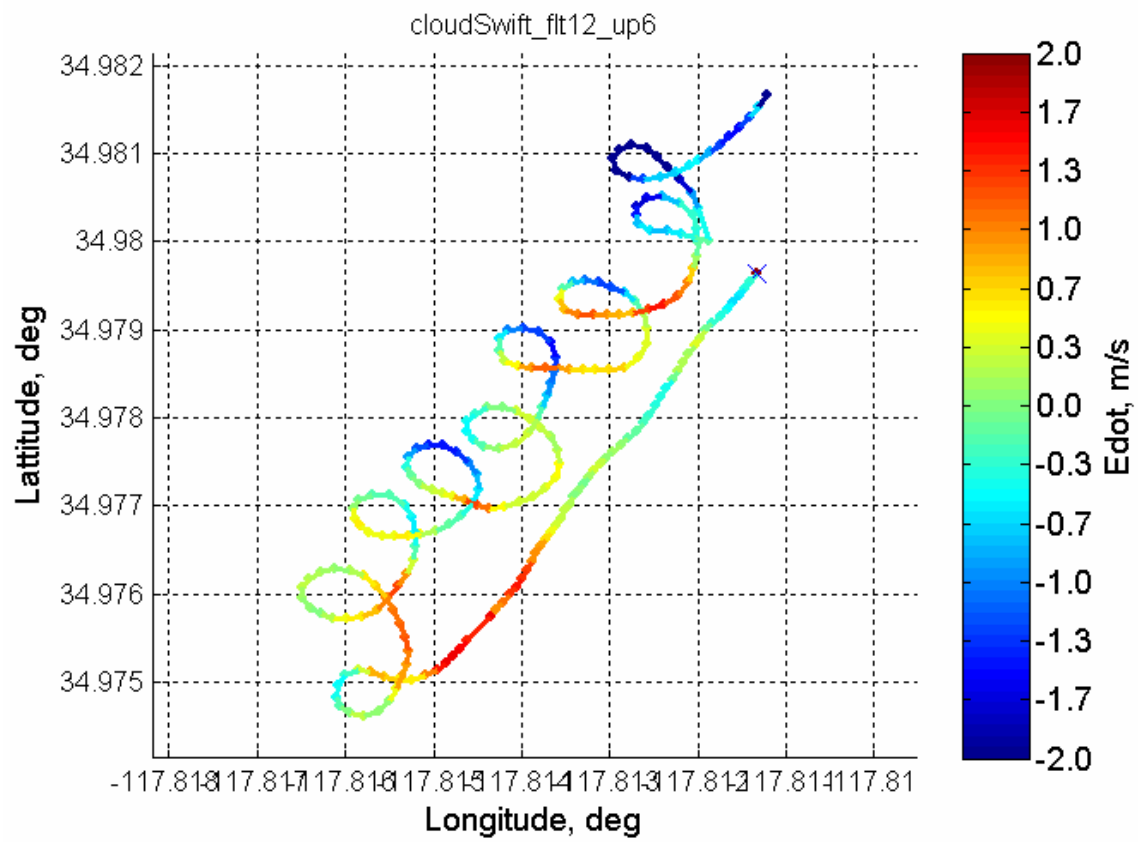


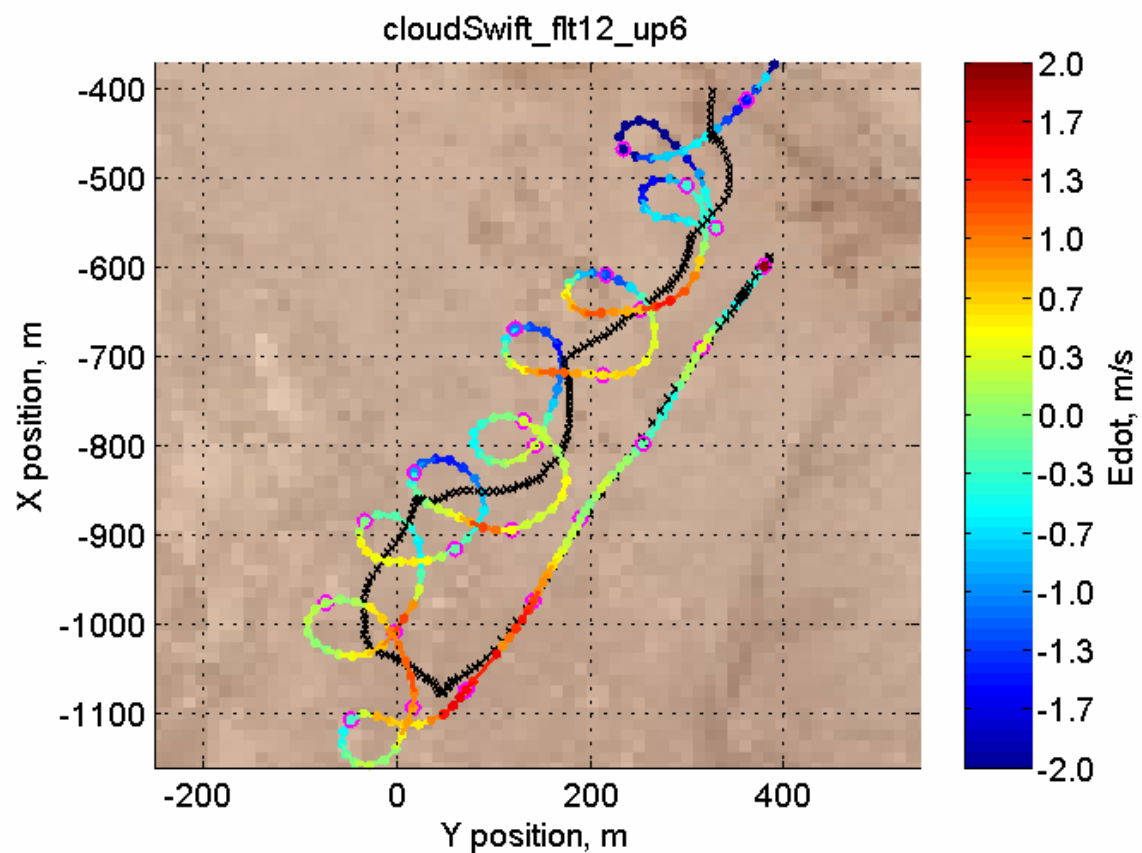
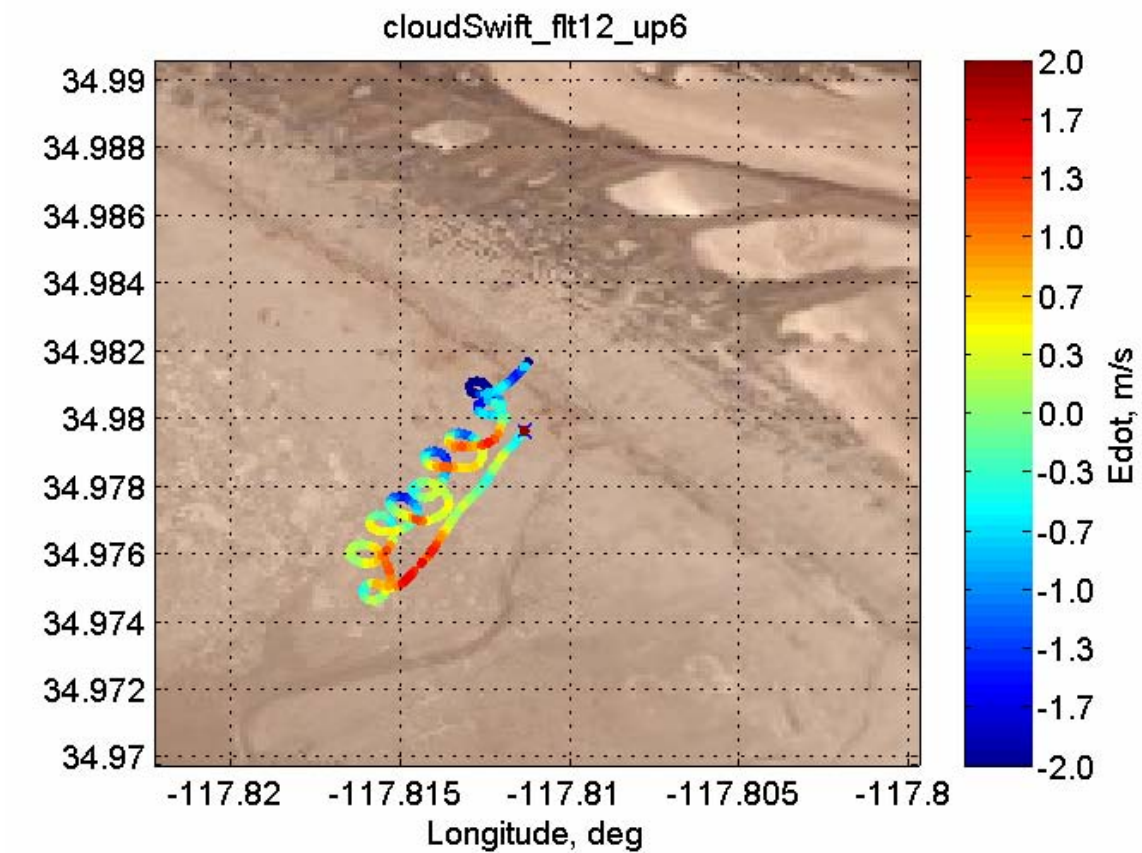


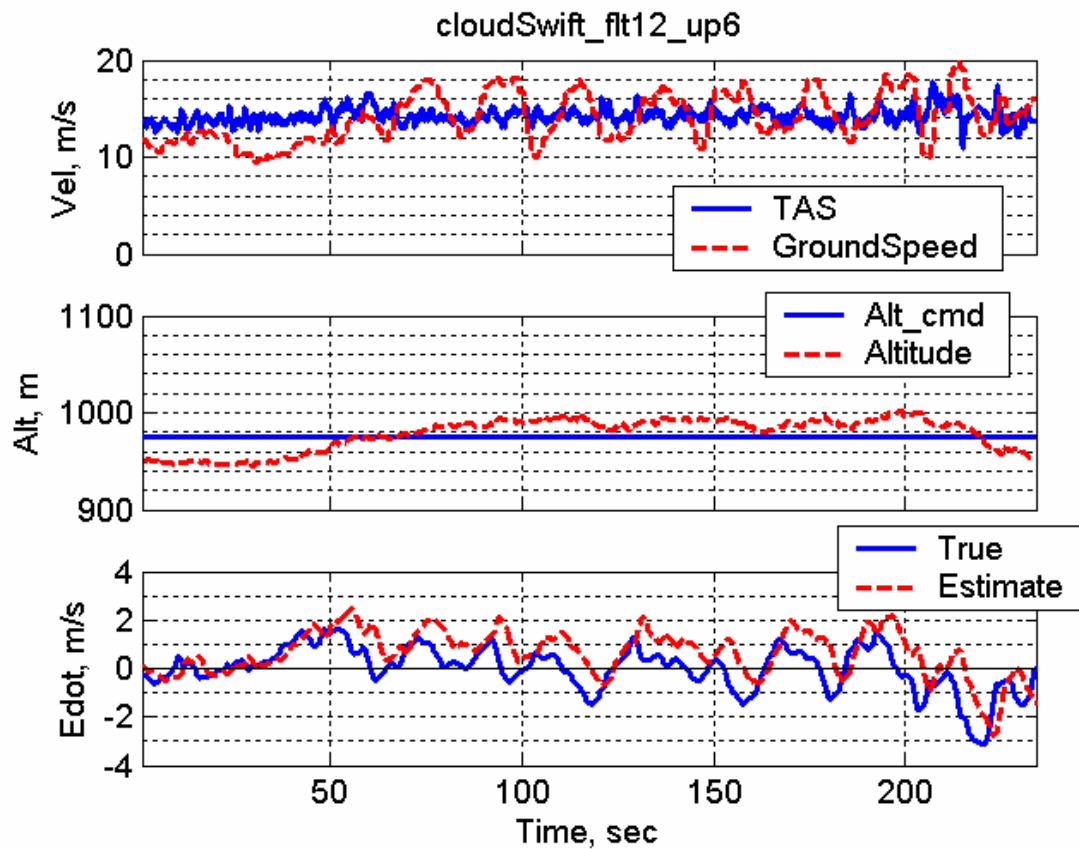
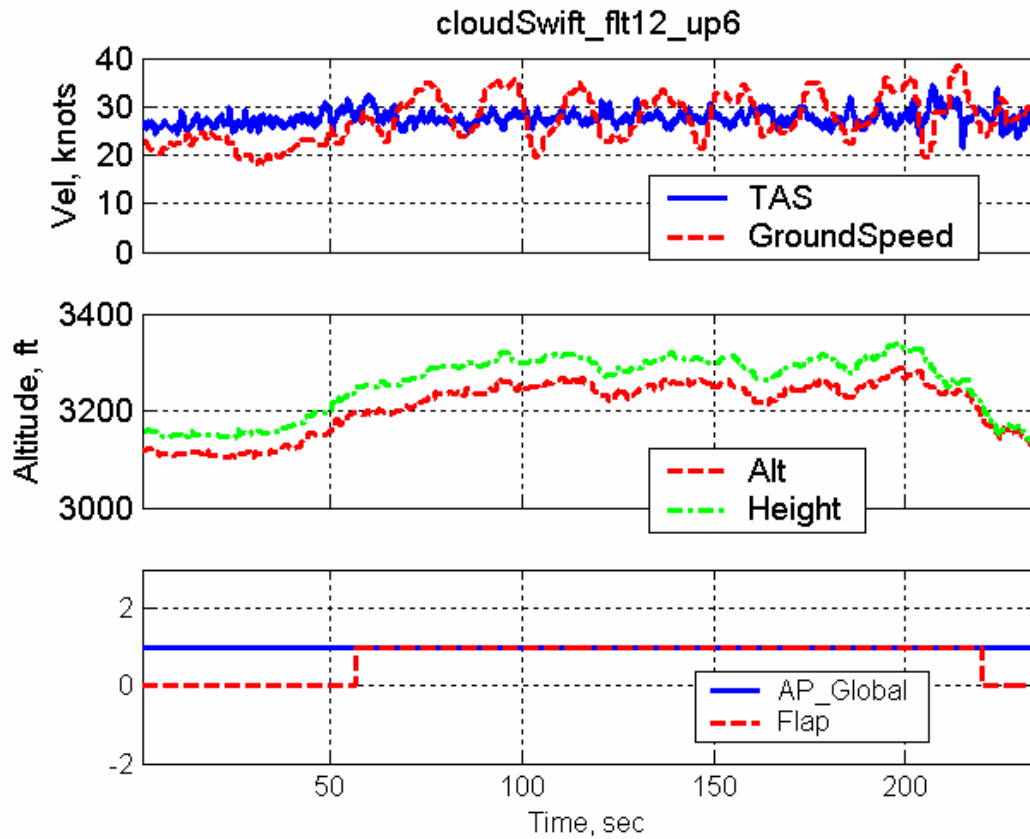


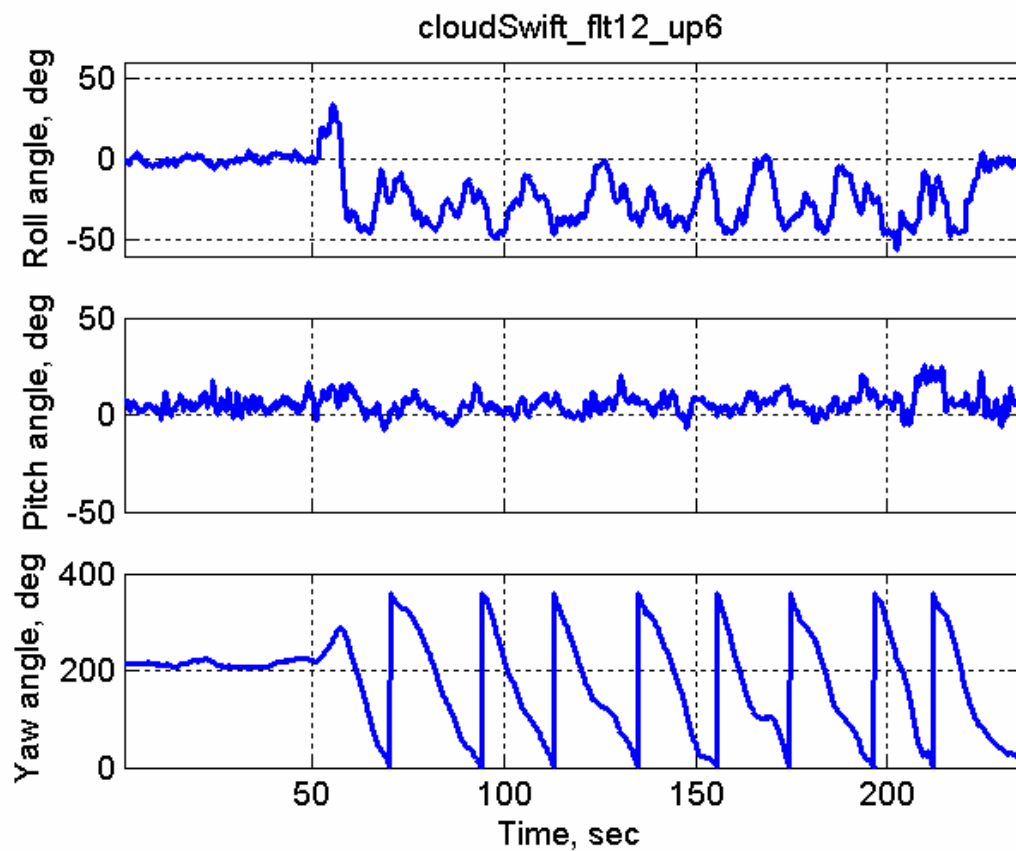
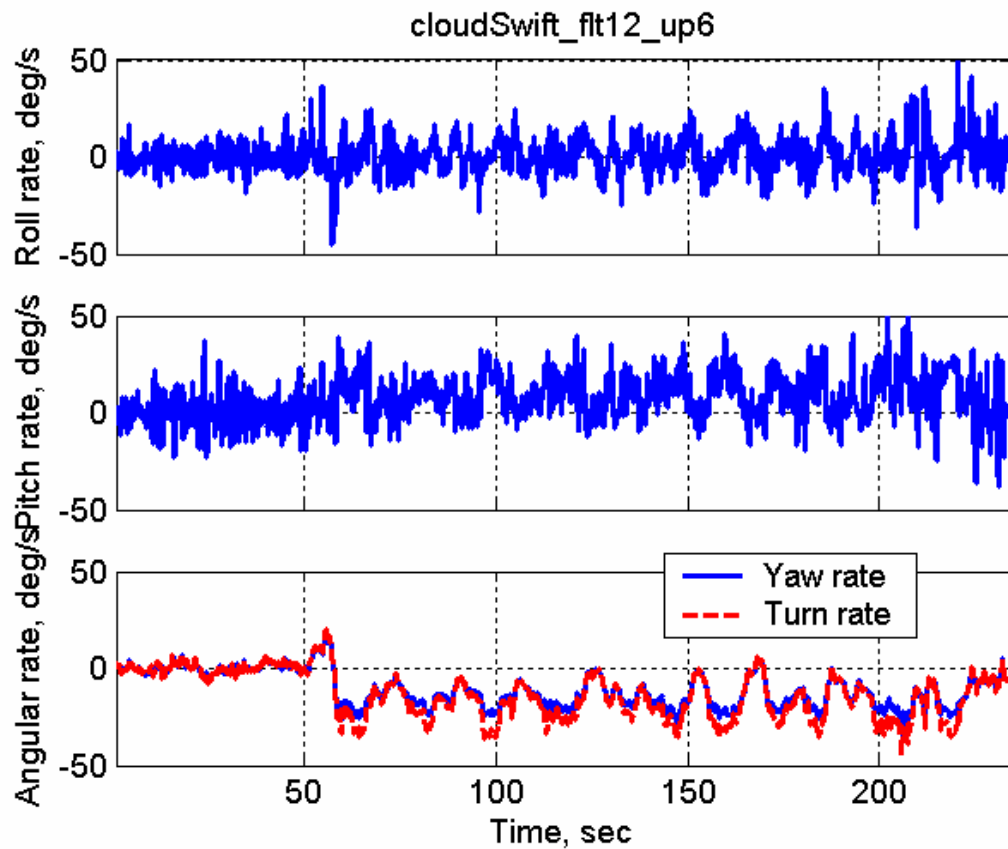
Flight 12, updraft 6

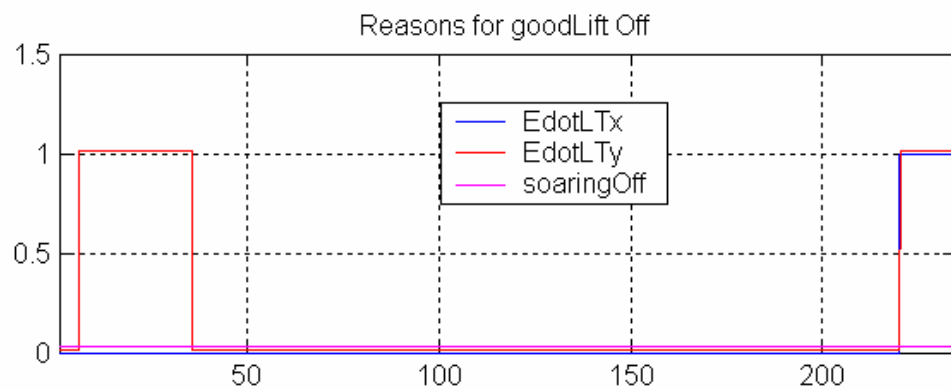
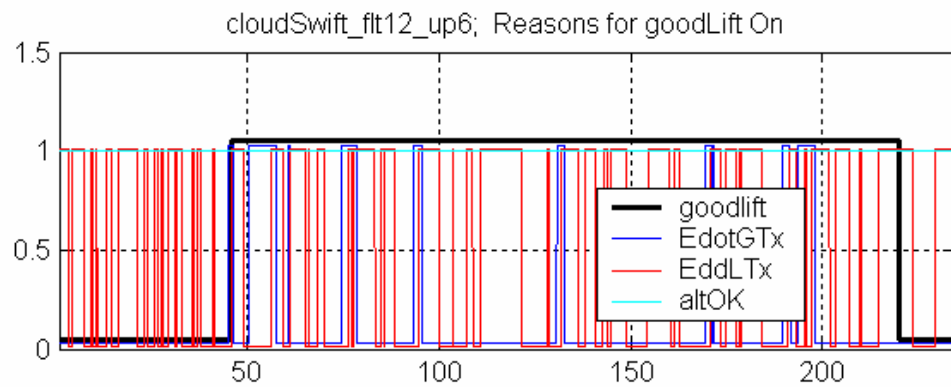
Good climb. fair centering. Late trigger. Jump and strong sink at end.

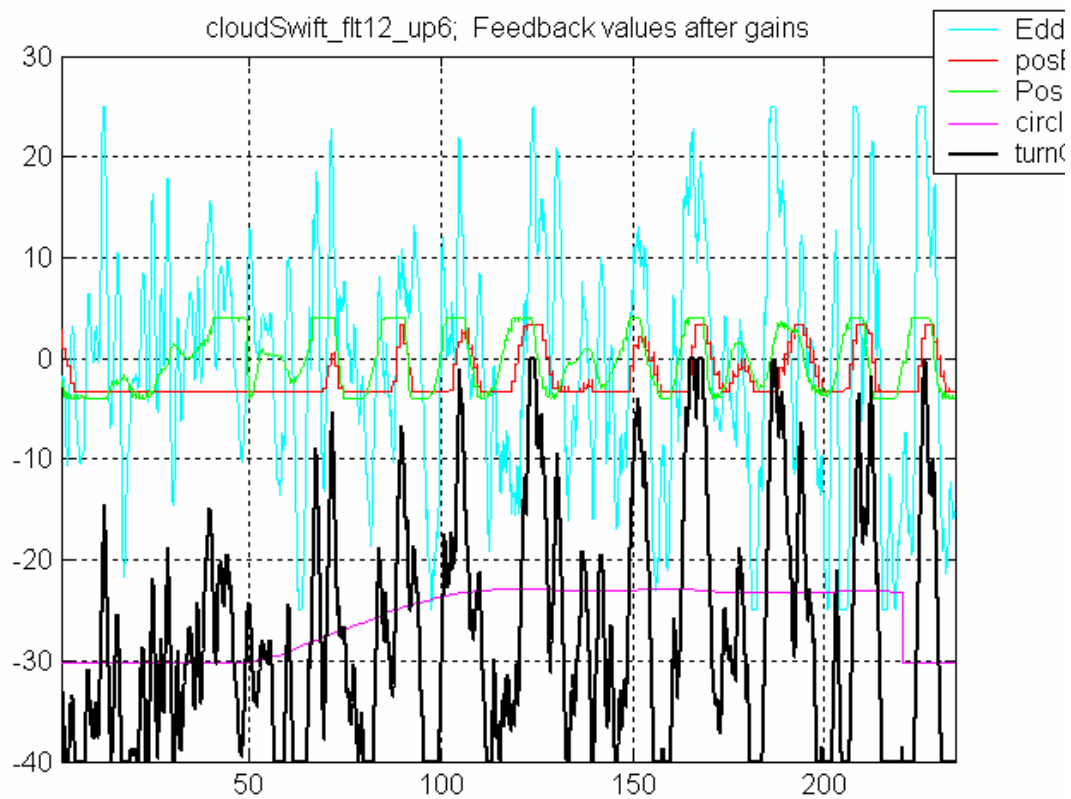
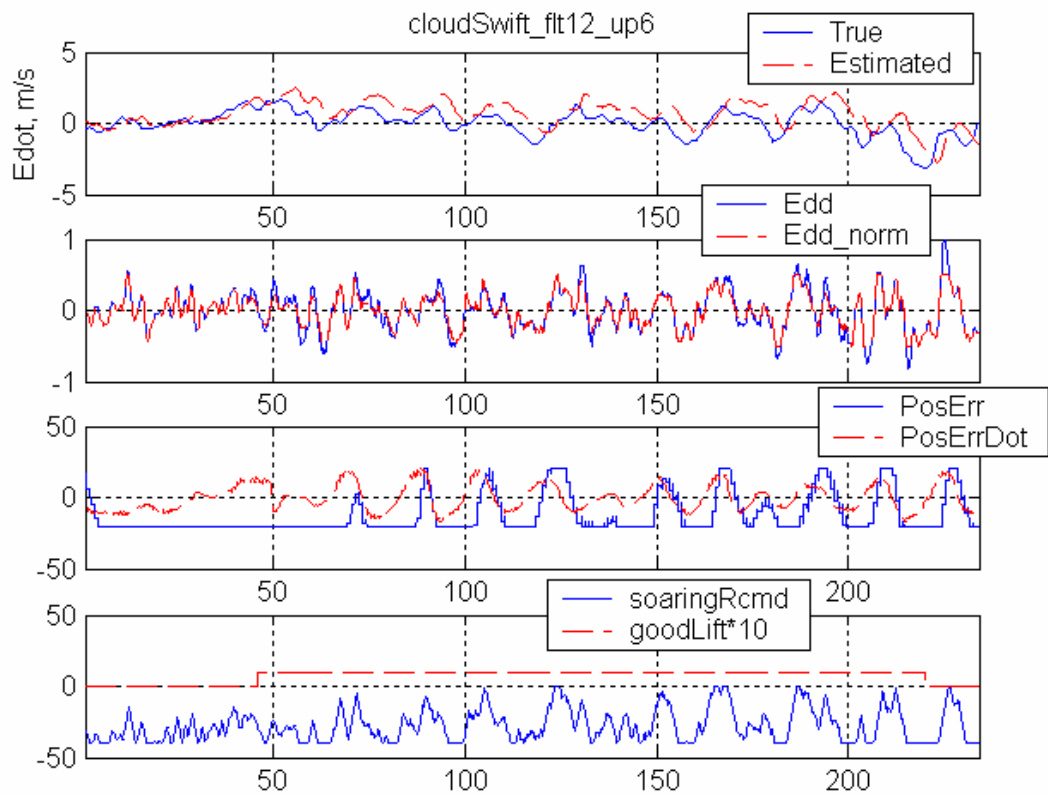






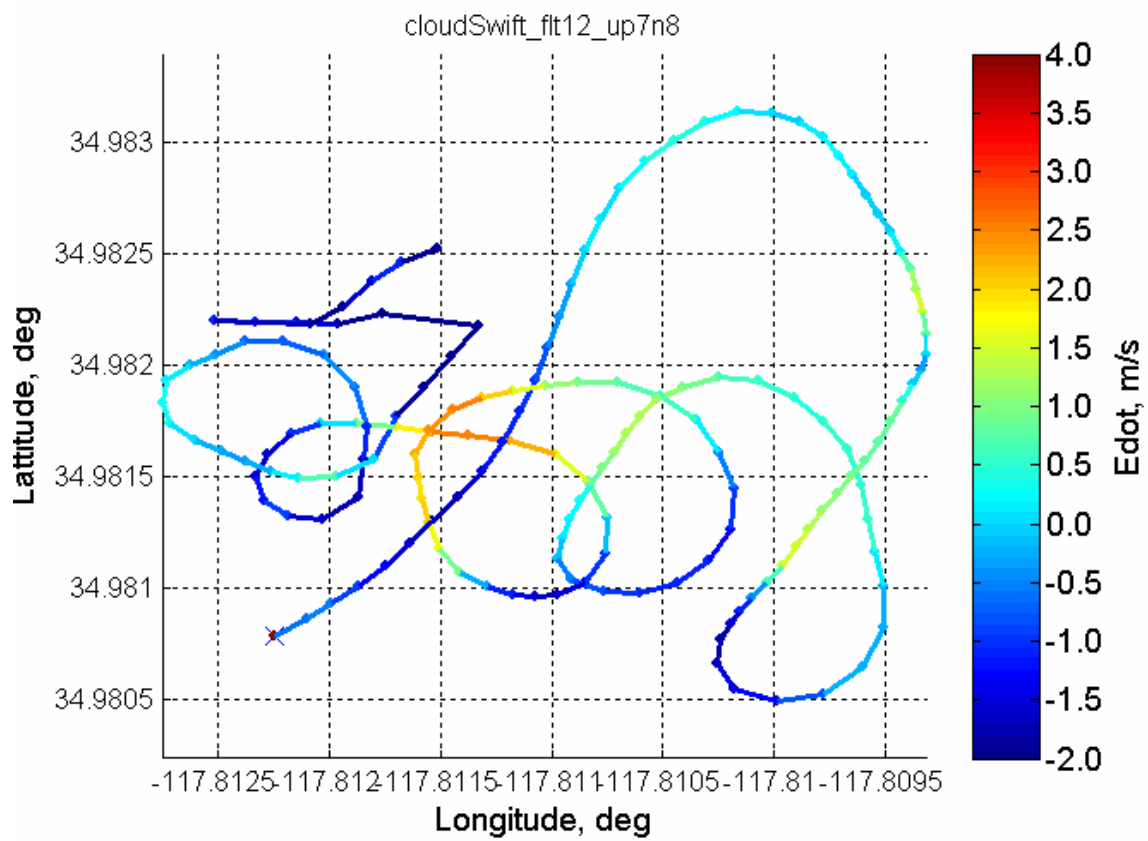


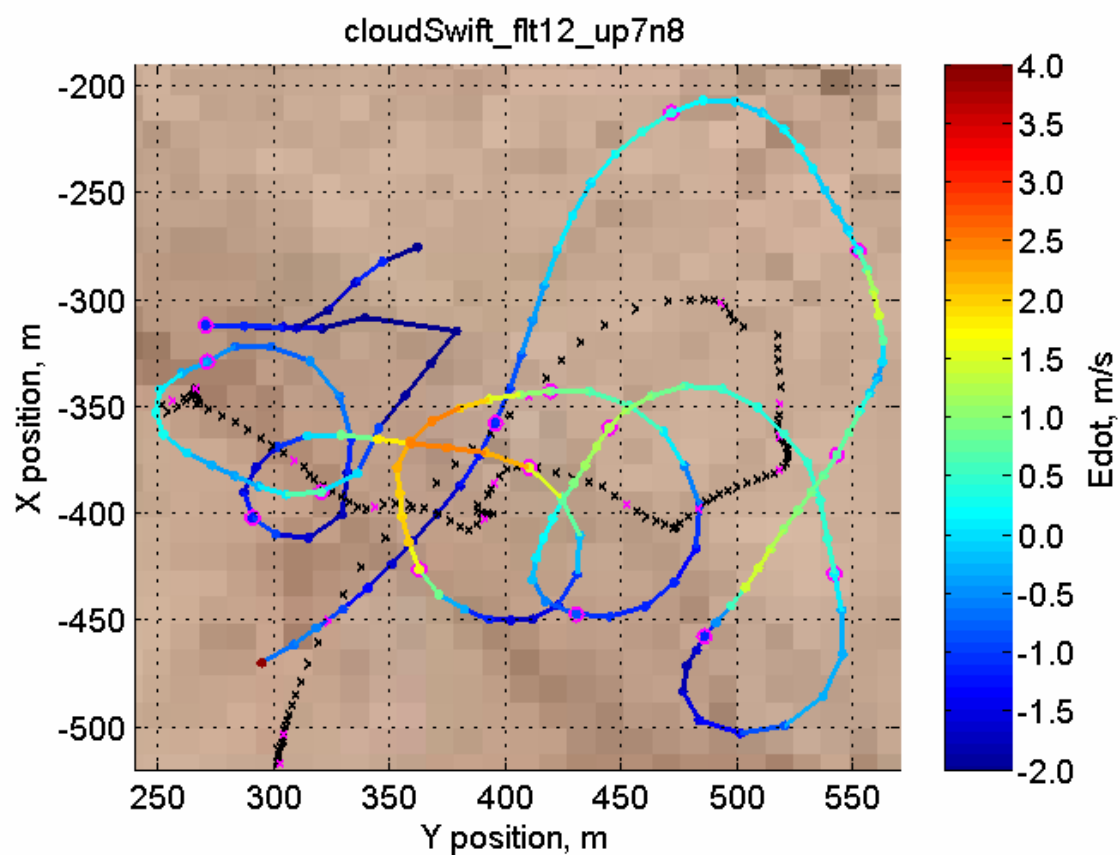
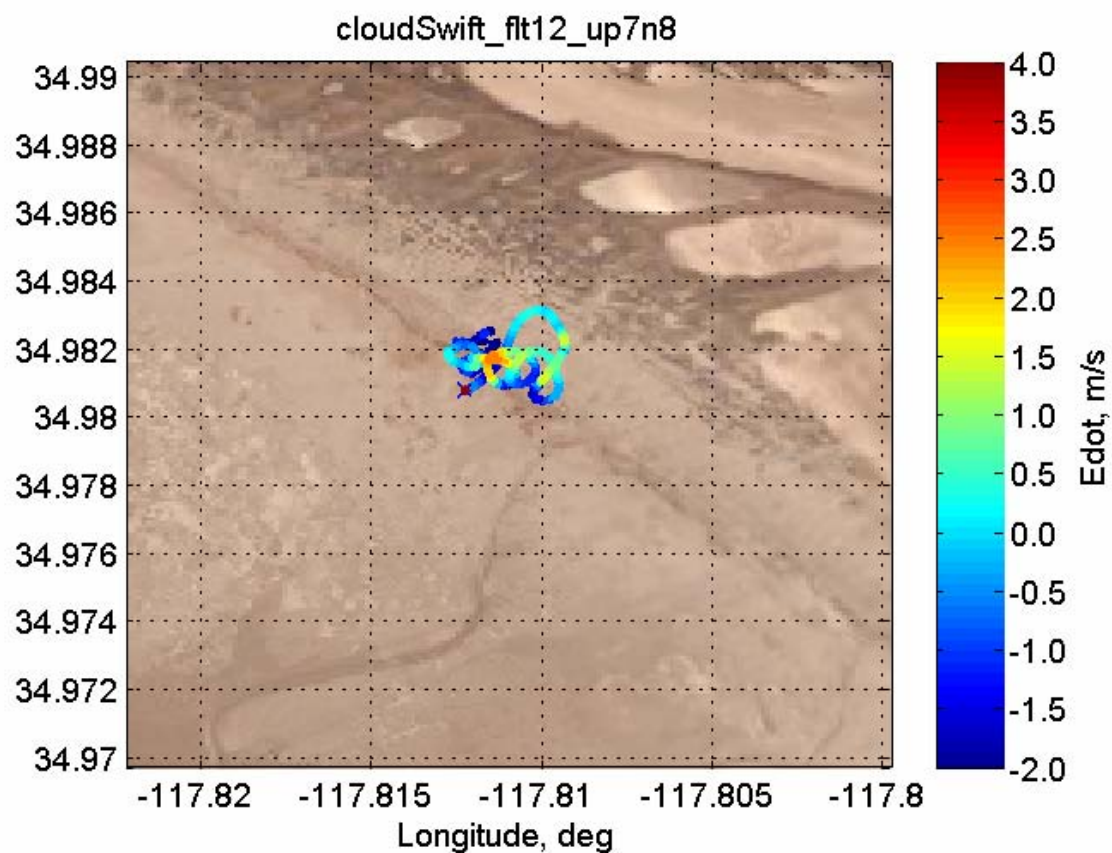


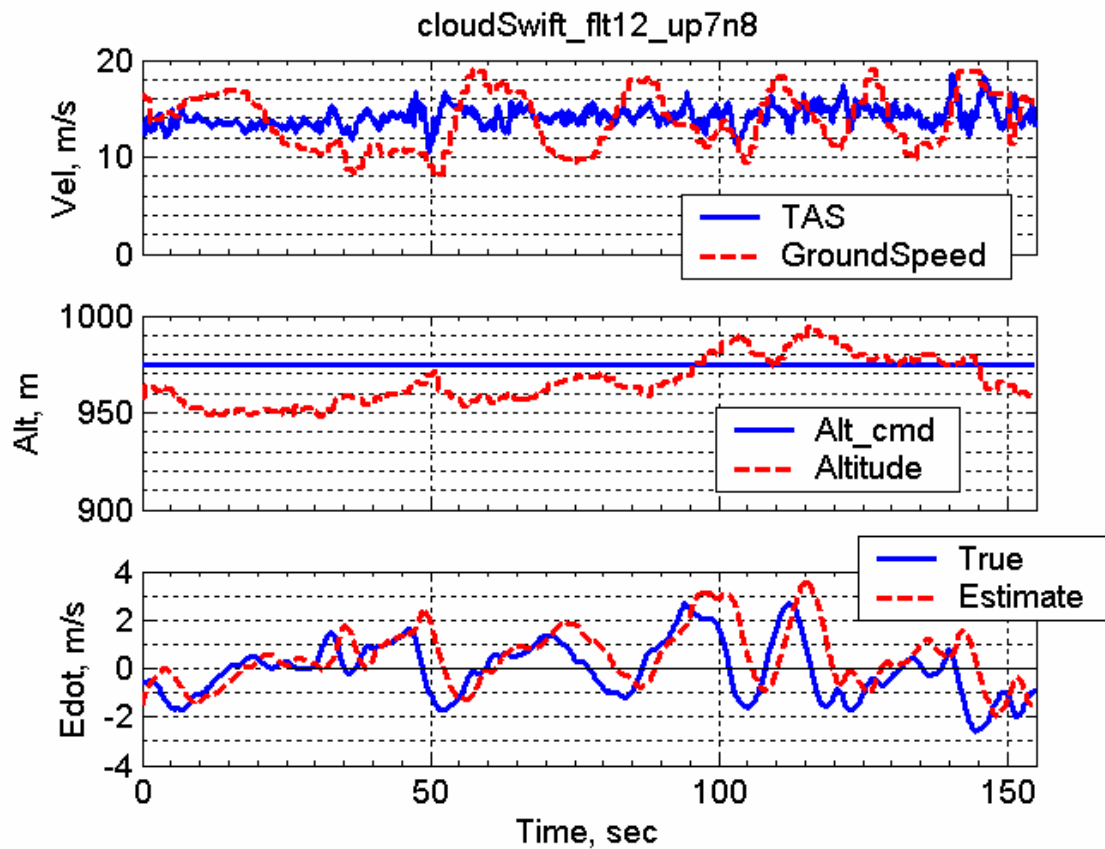
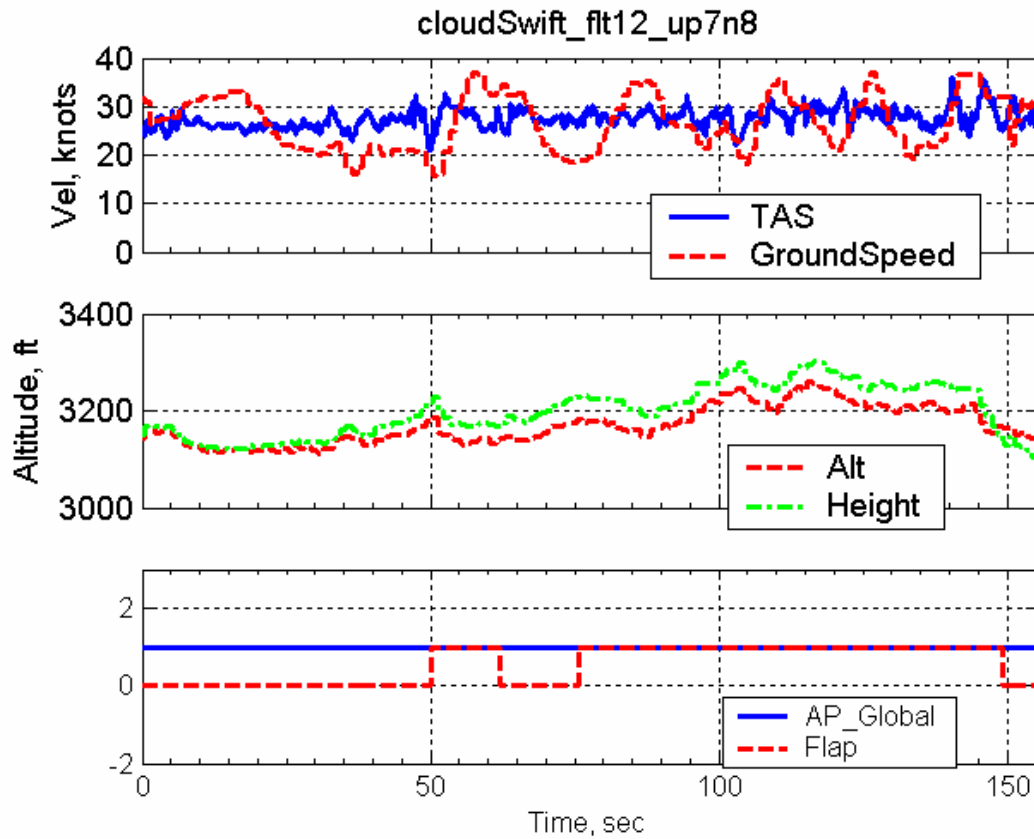


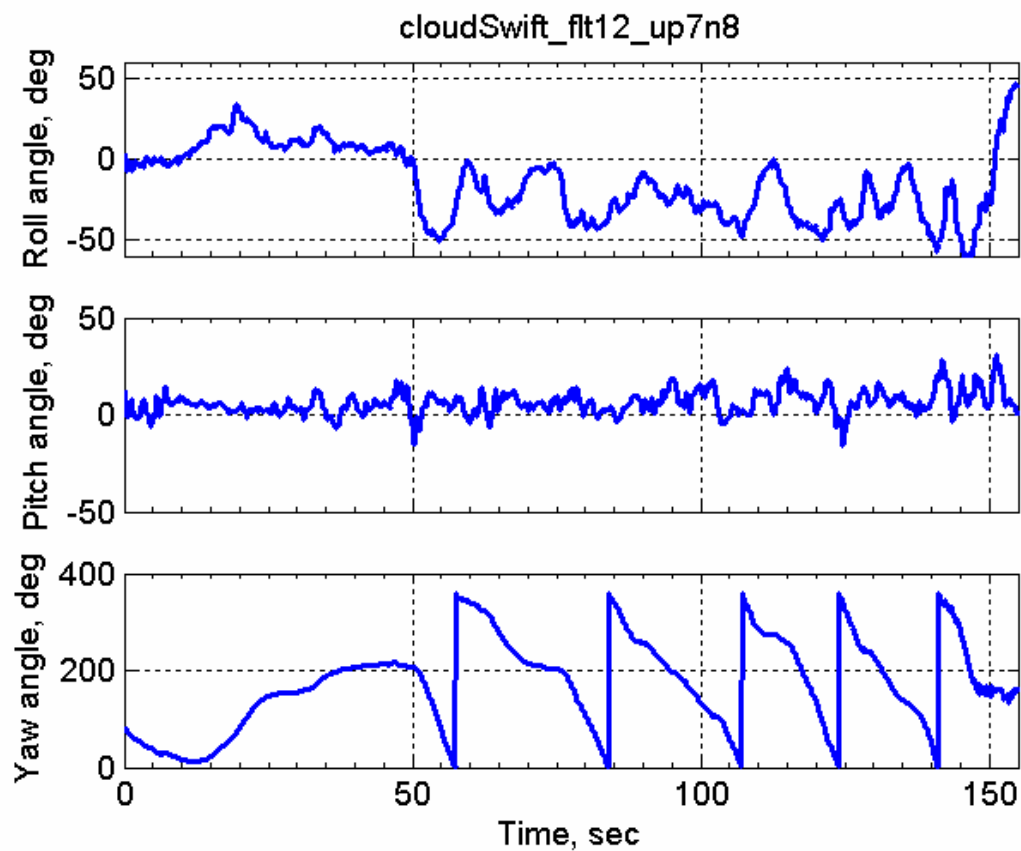
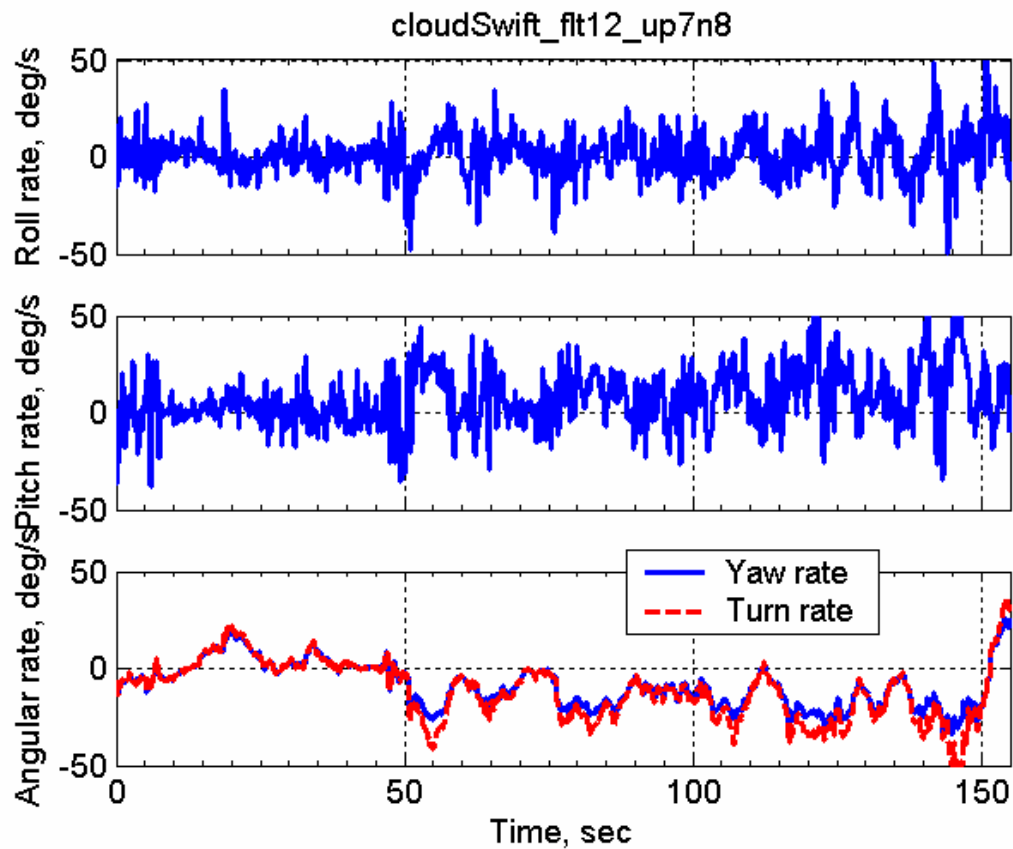
Flight 12, updrafts 7 & 8

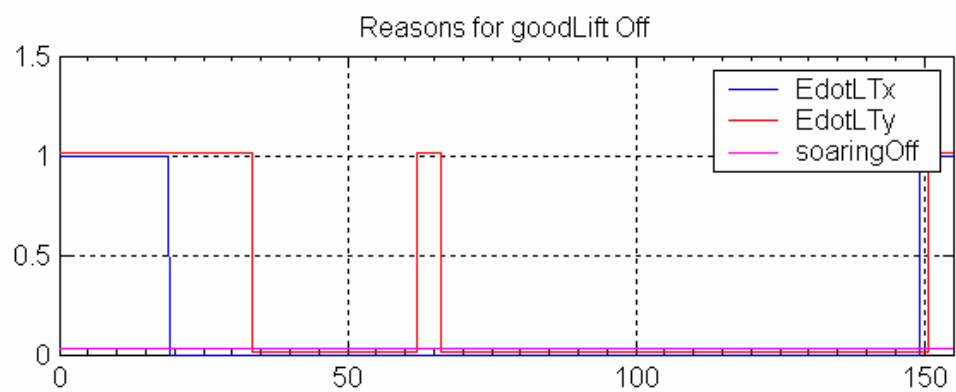
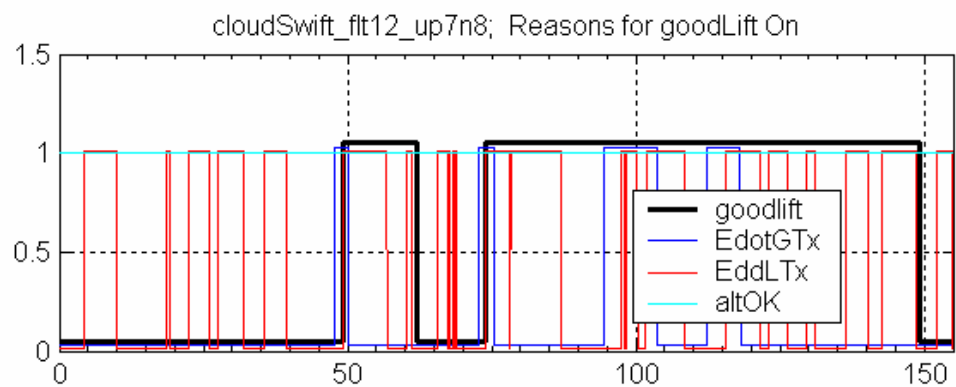
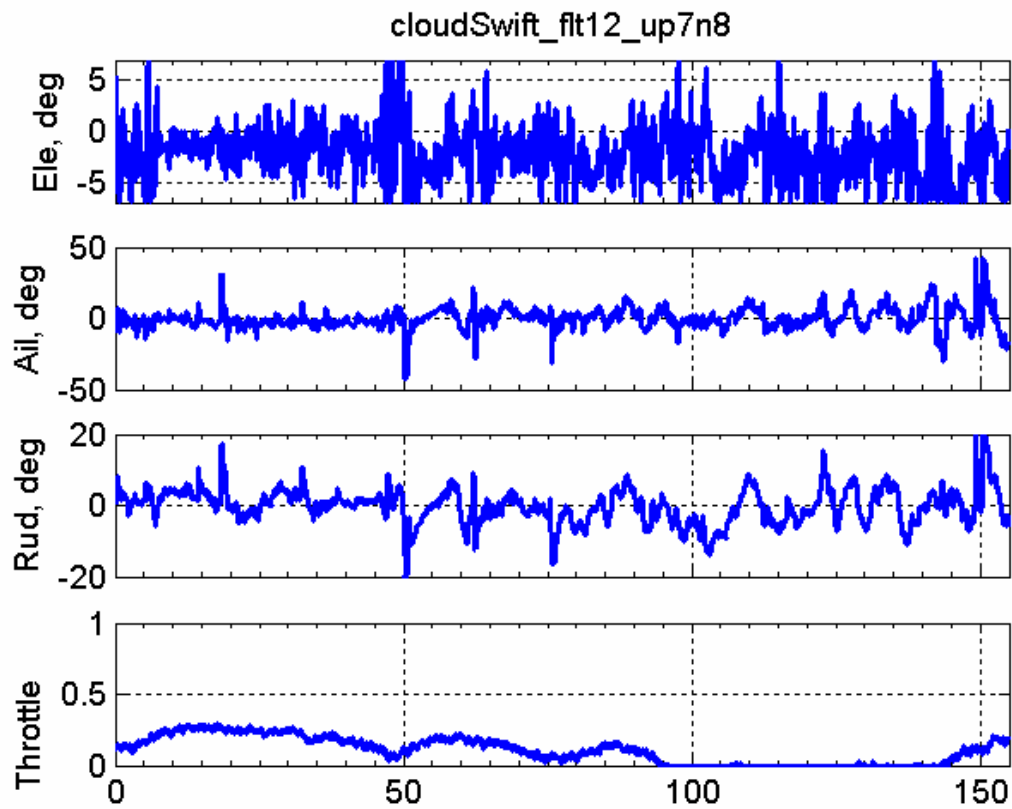
Lift seems to shift and change. Controller does not follow too well. GPS problem at end.

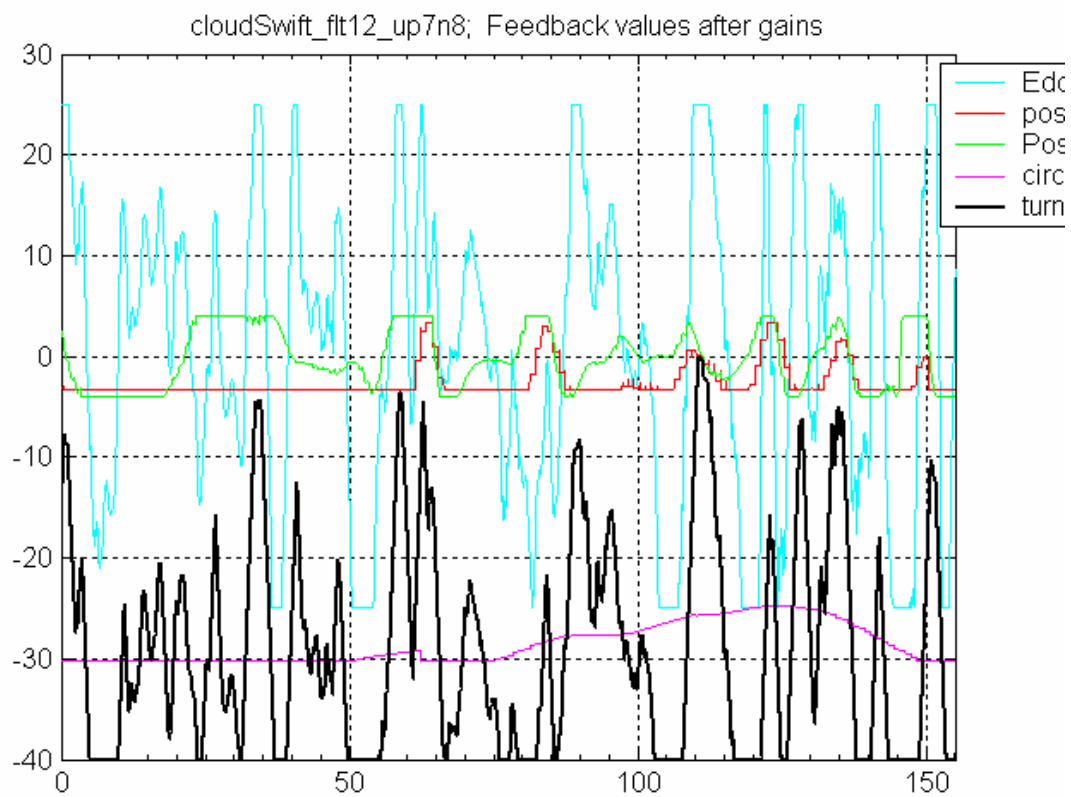
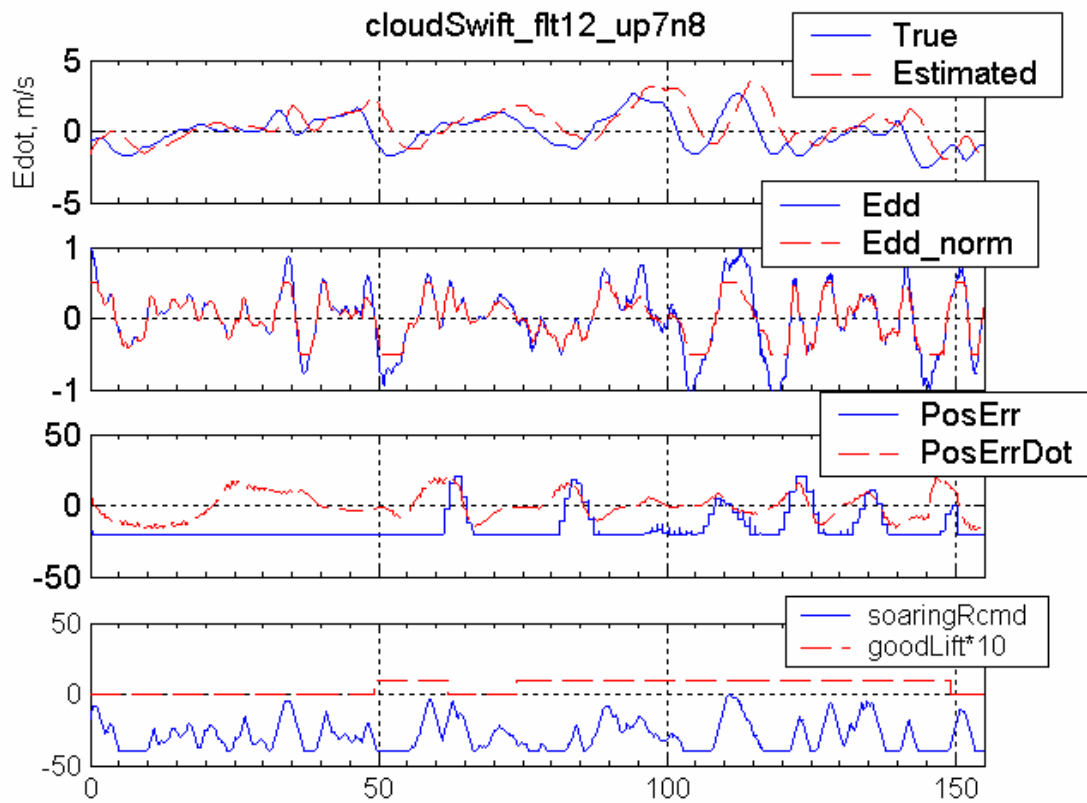






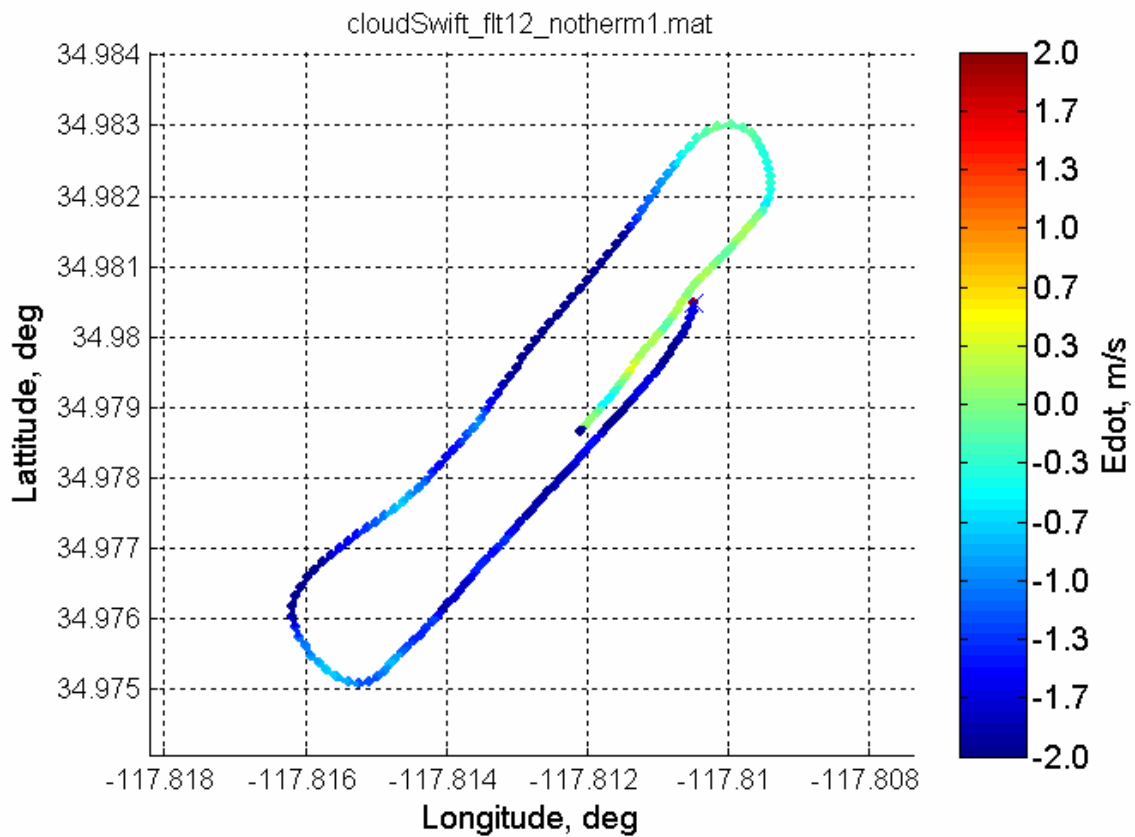


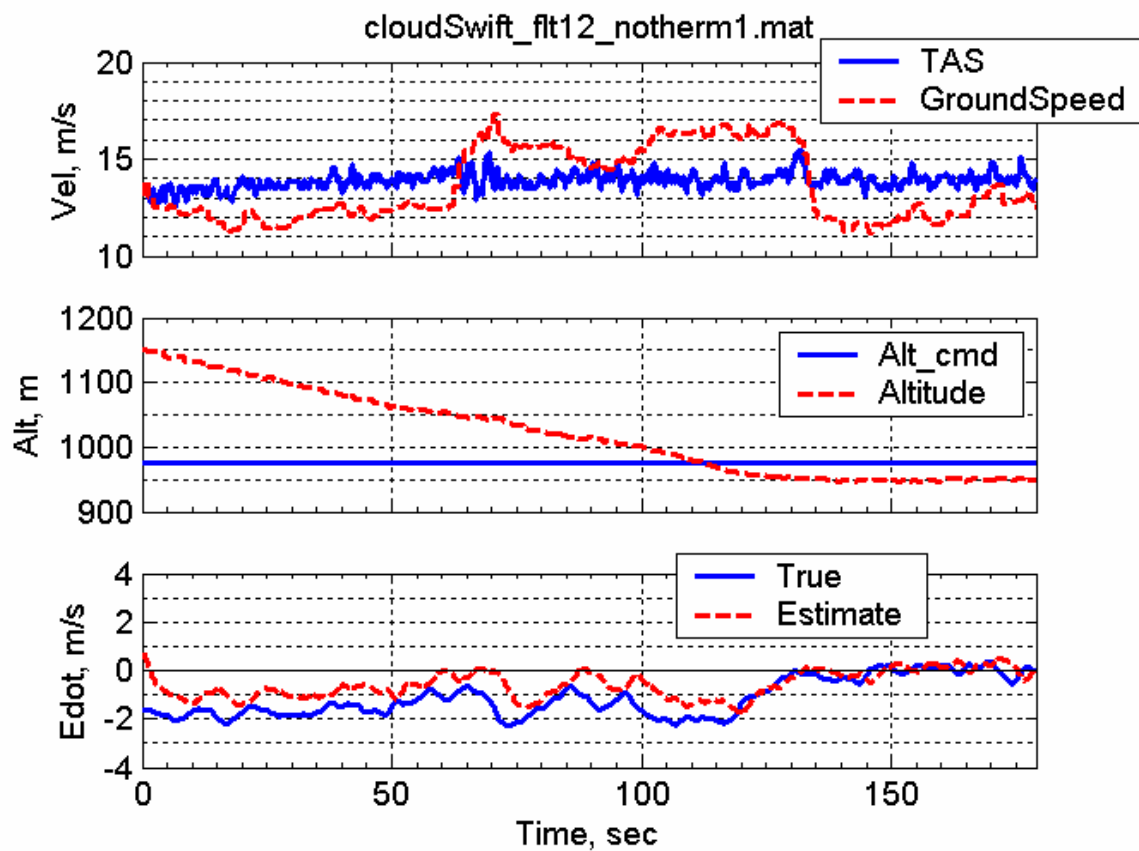
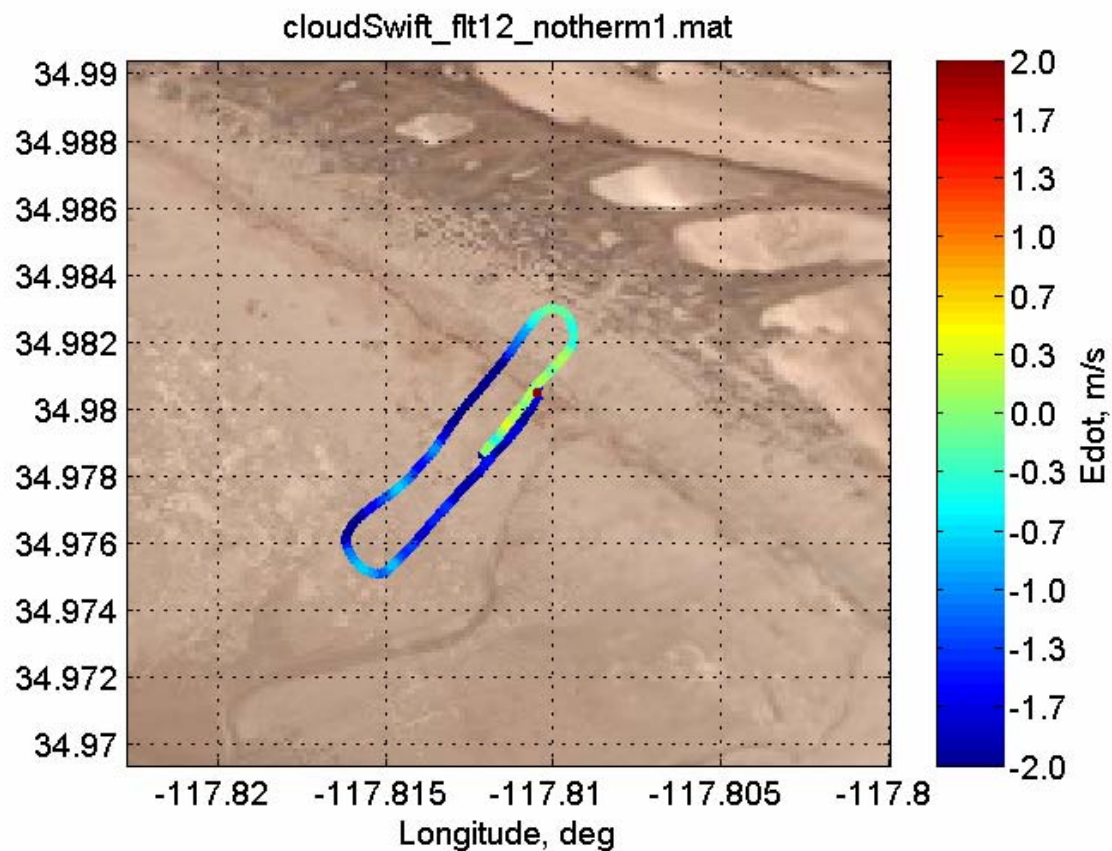


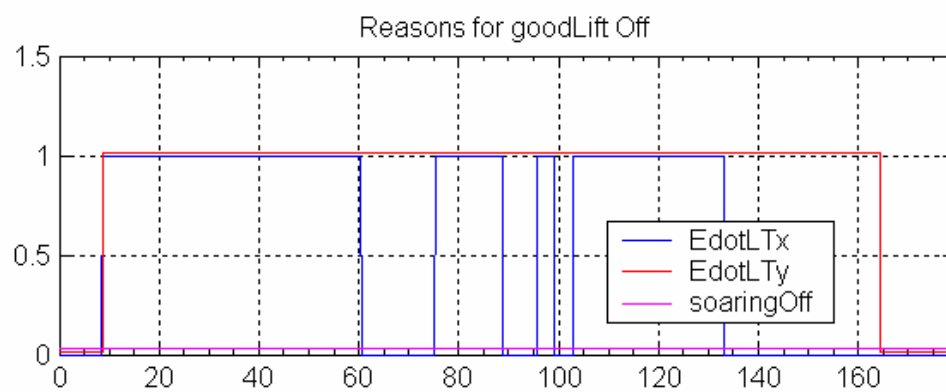
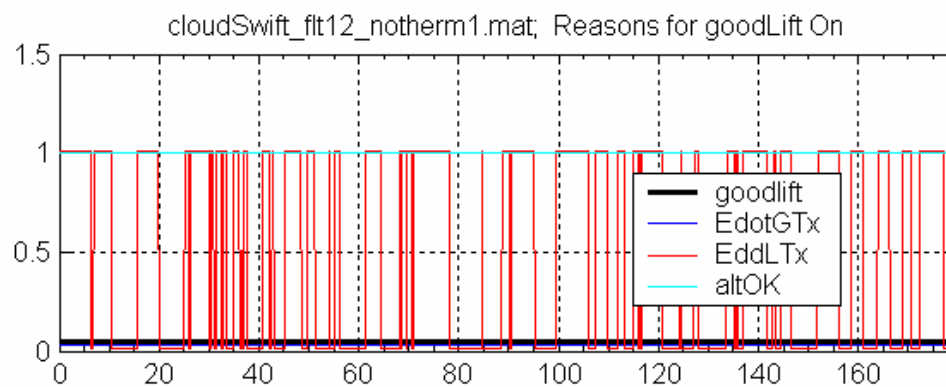
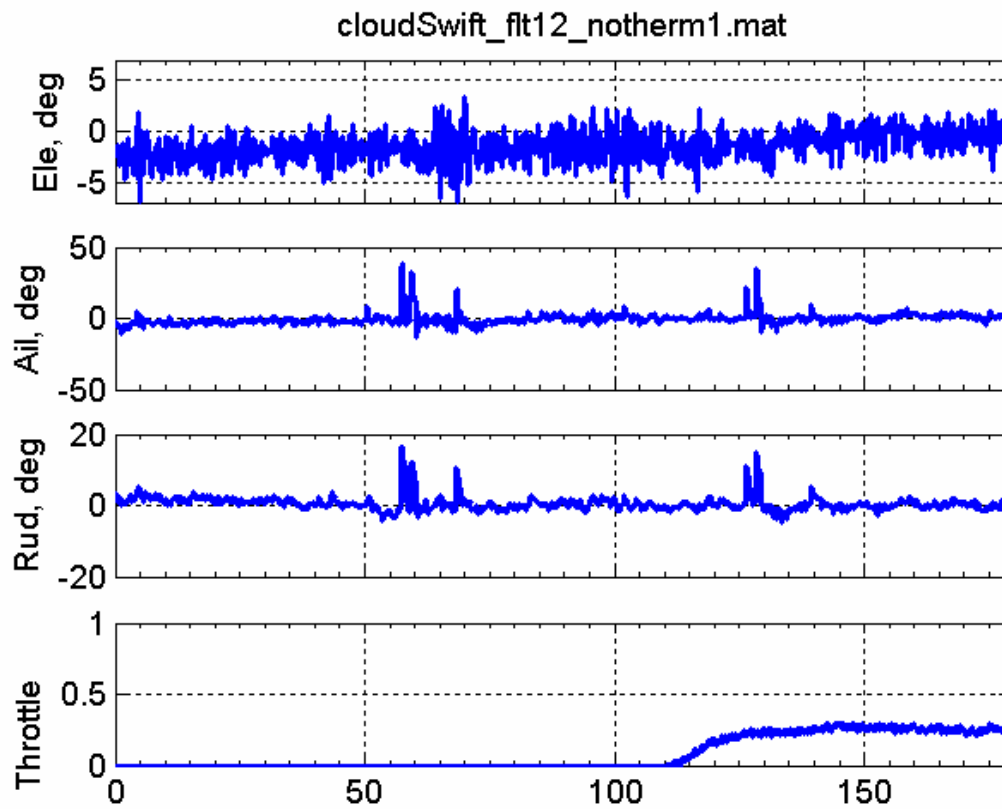


Flight 12, no thermals 1

Dead spell in middle of flight. No thermals detected. Long period of gliding flight until commanded altitude is reached and motor comes on.

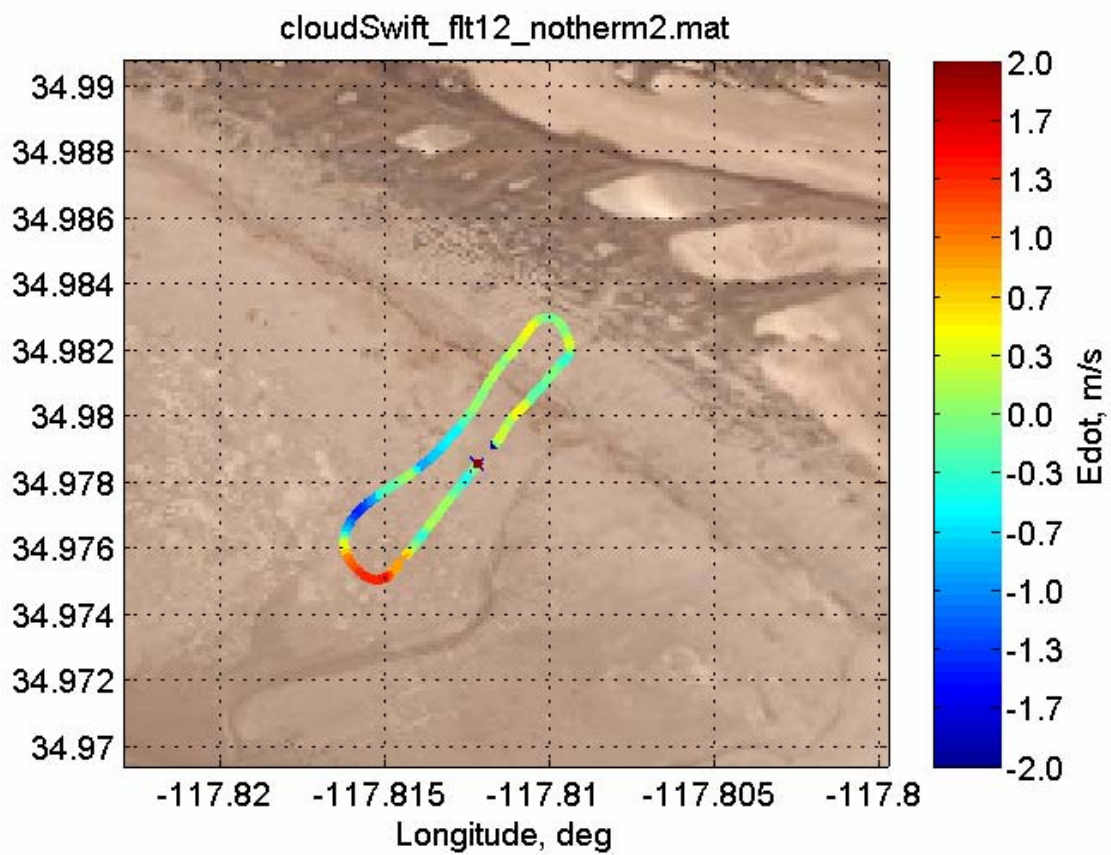


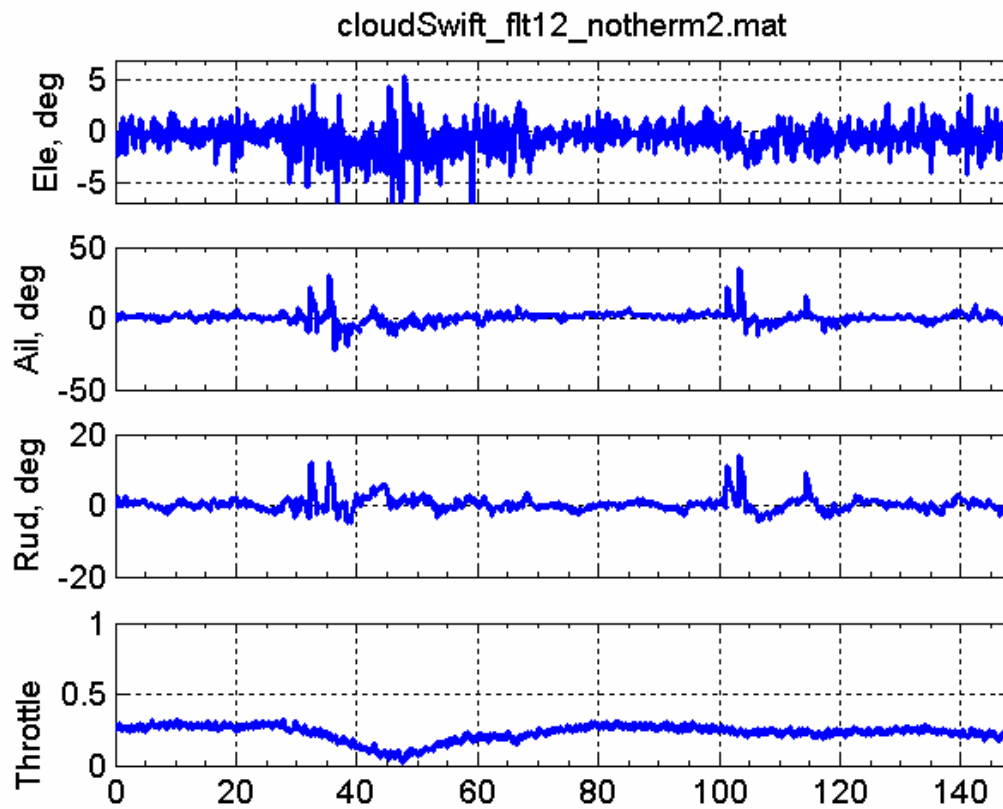
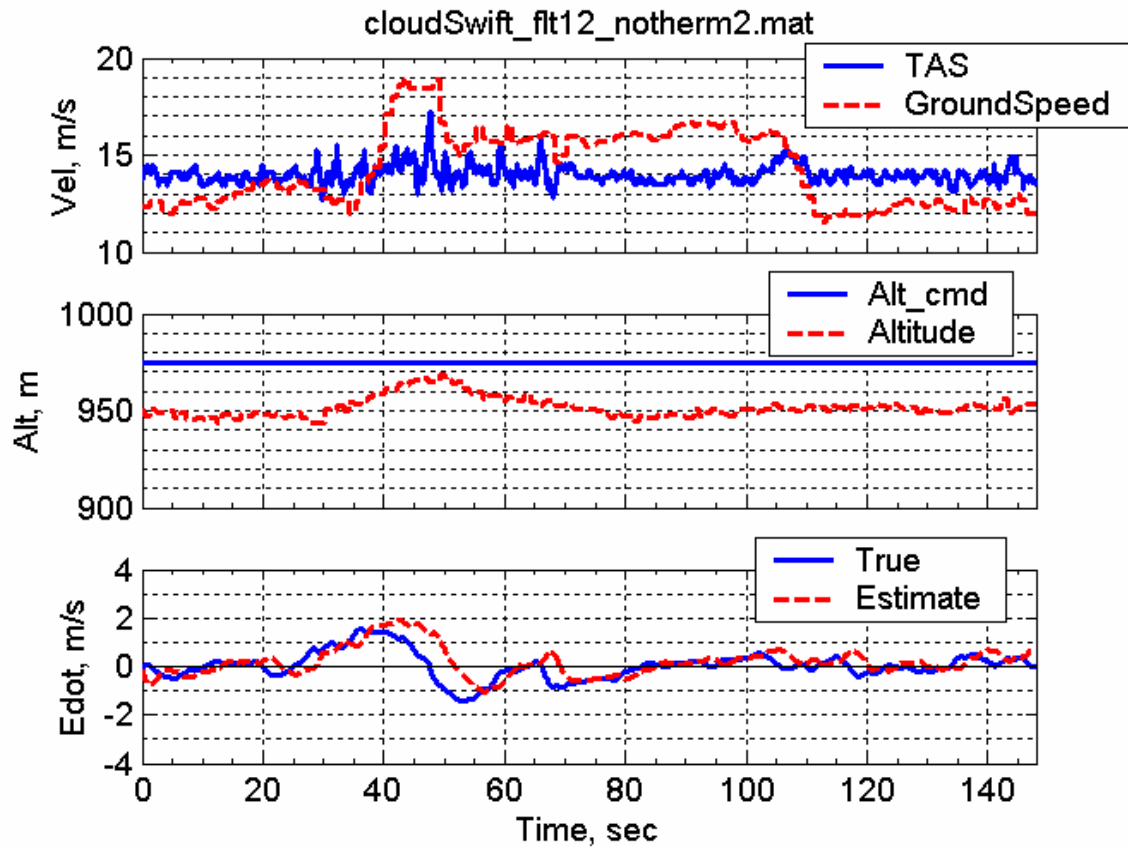


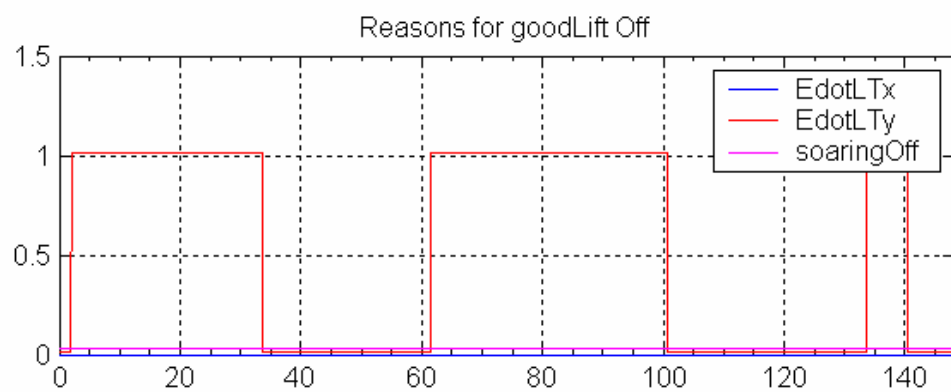
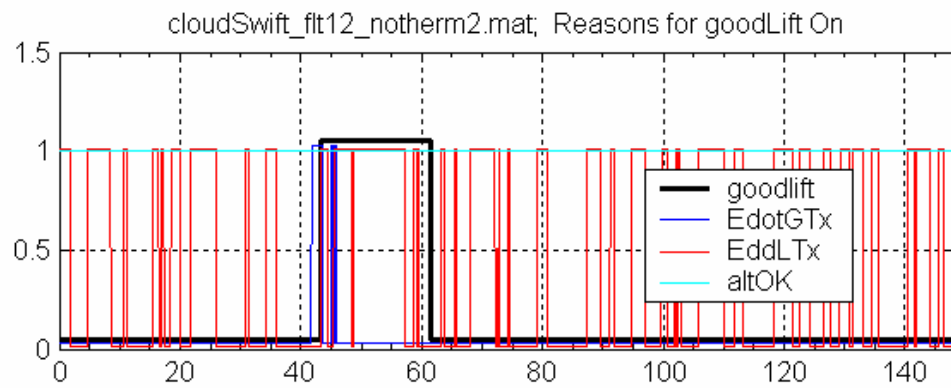


Flight 12, no thermals 2

Replay of flight data shows that soaring mode should have tripped on. Was soaring disabled by the ground station operator? Need to check .tel file.

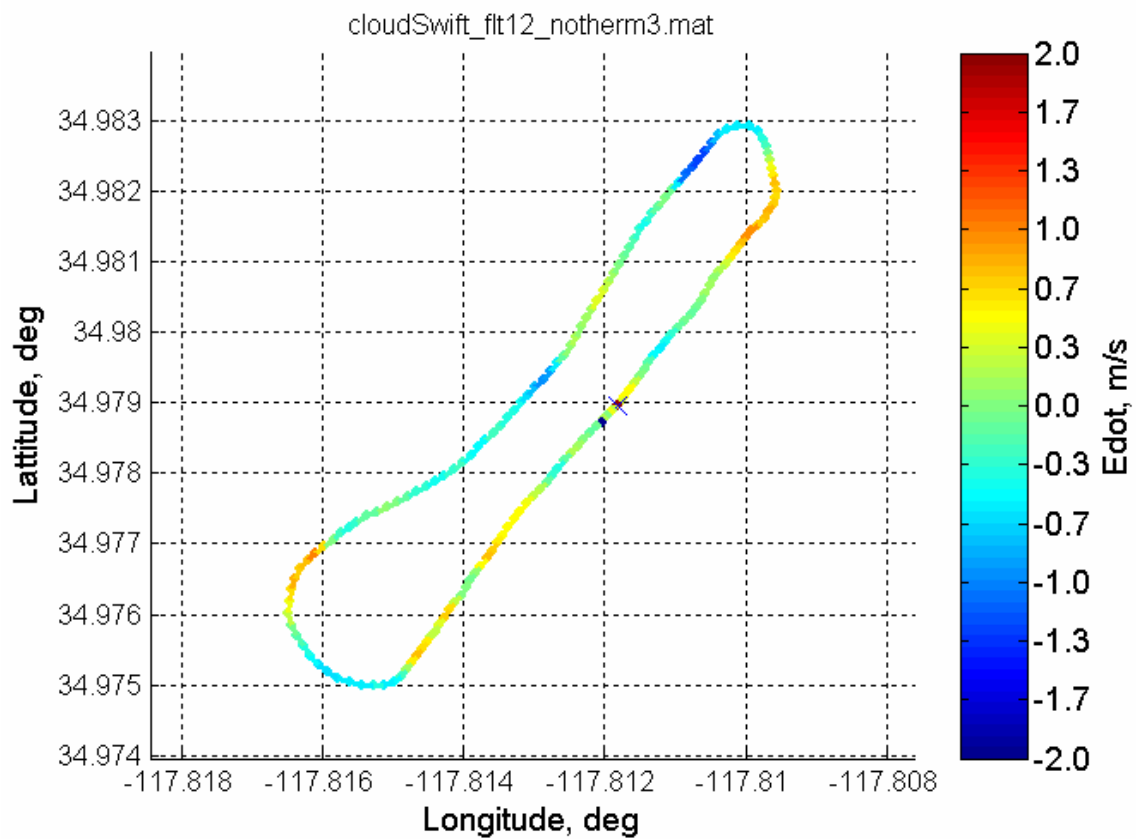


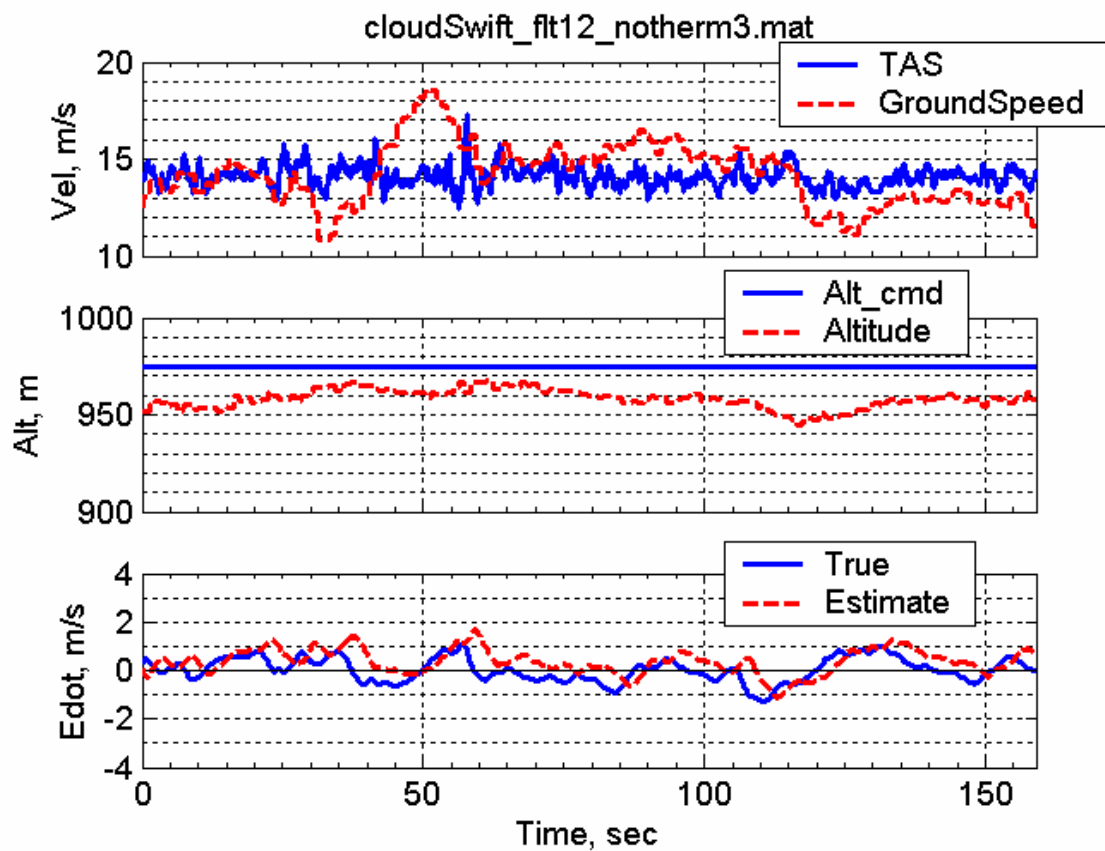
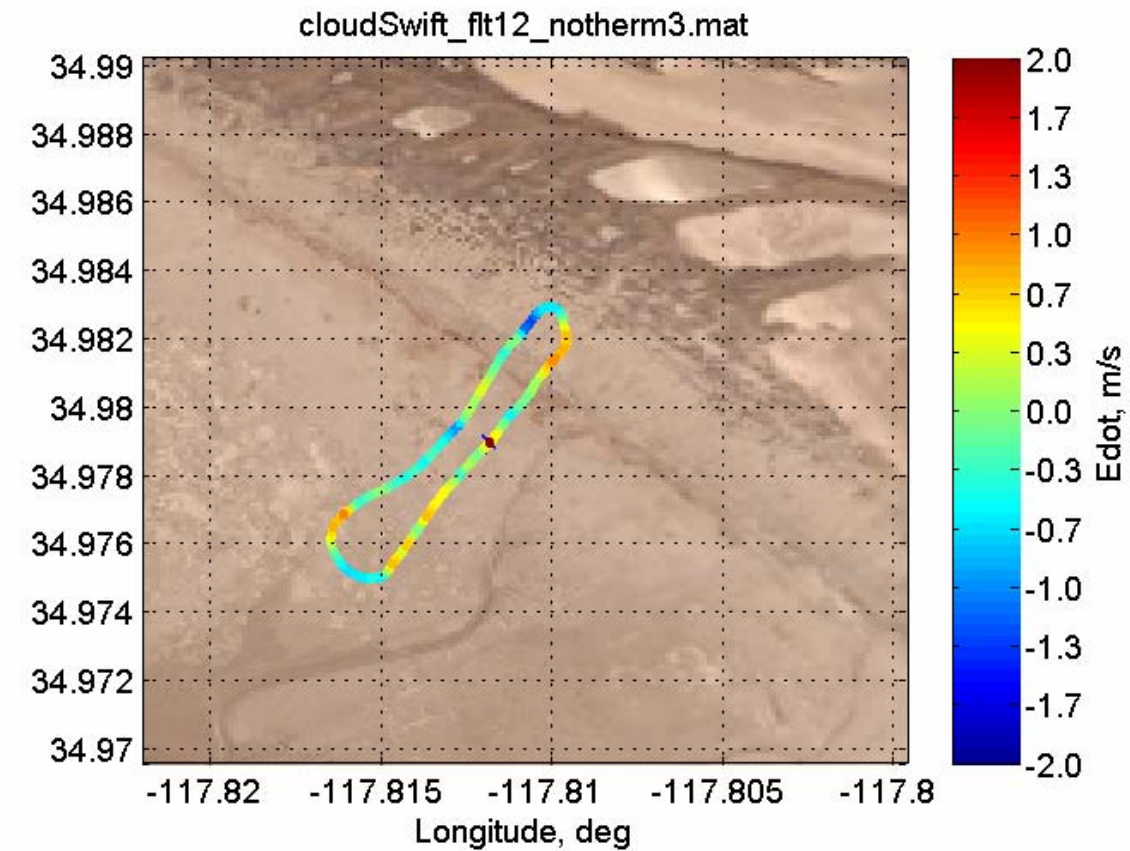


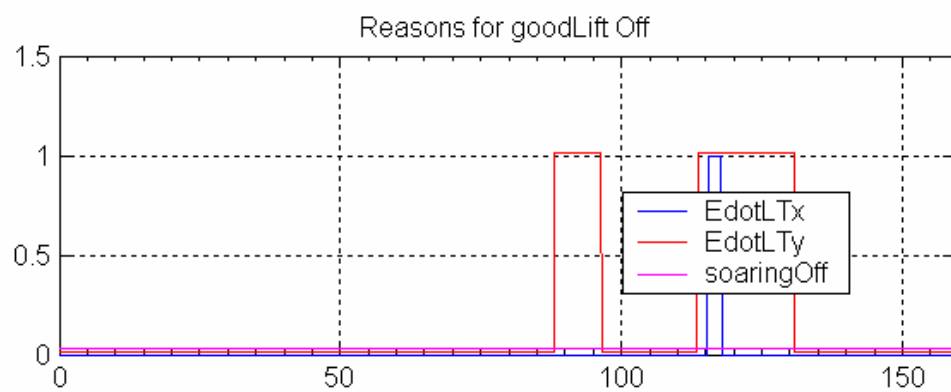
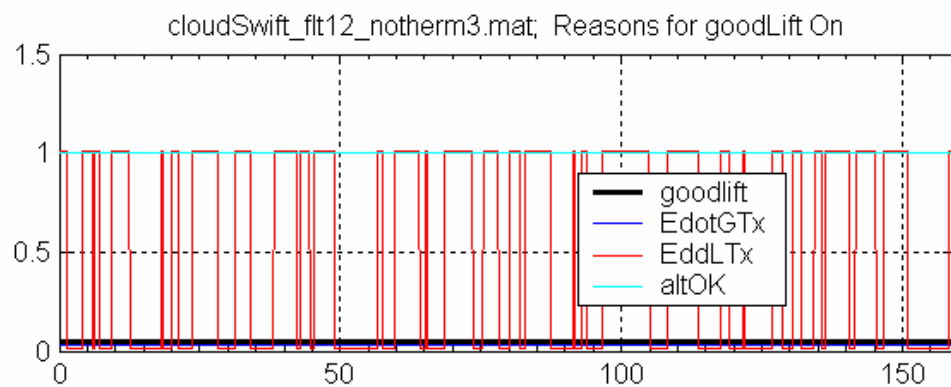
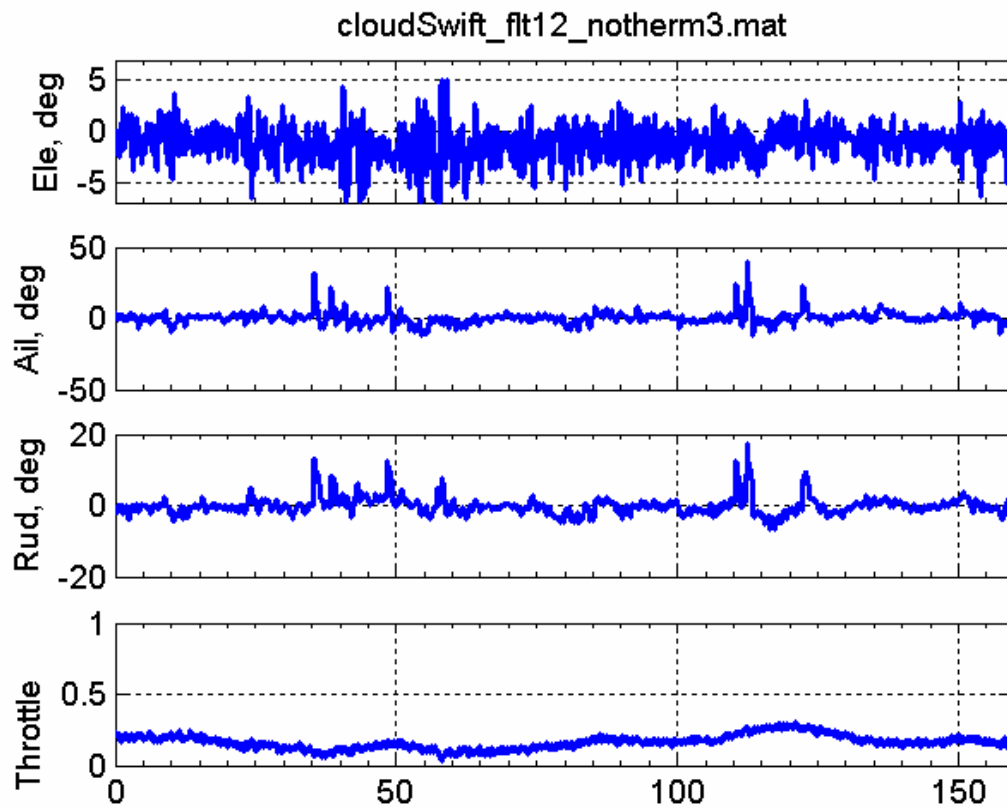


Flight 12, no thermals 3

Nearly big enough lift. Wind causes large difference in vel & groundspeed. Smarter soaring algorithms would stop and investigate this thermal before moving on.

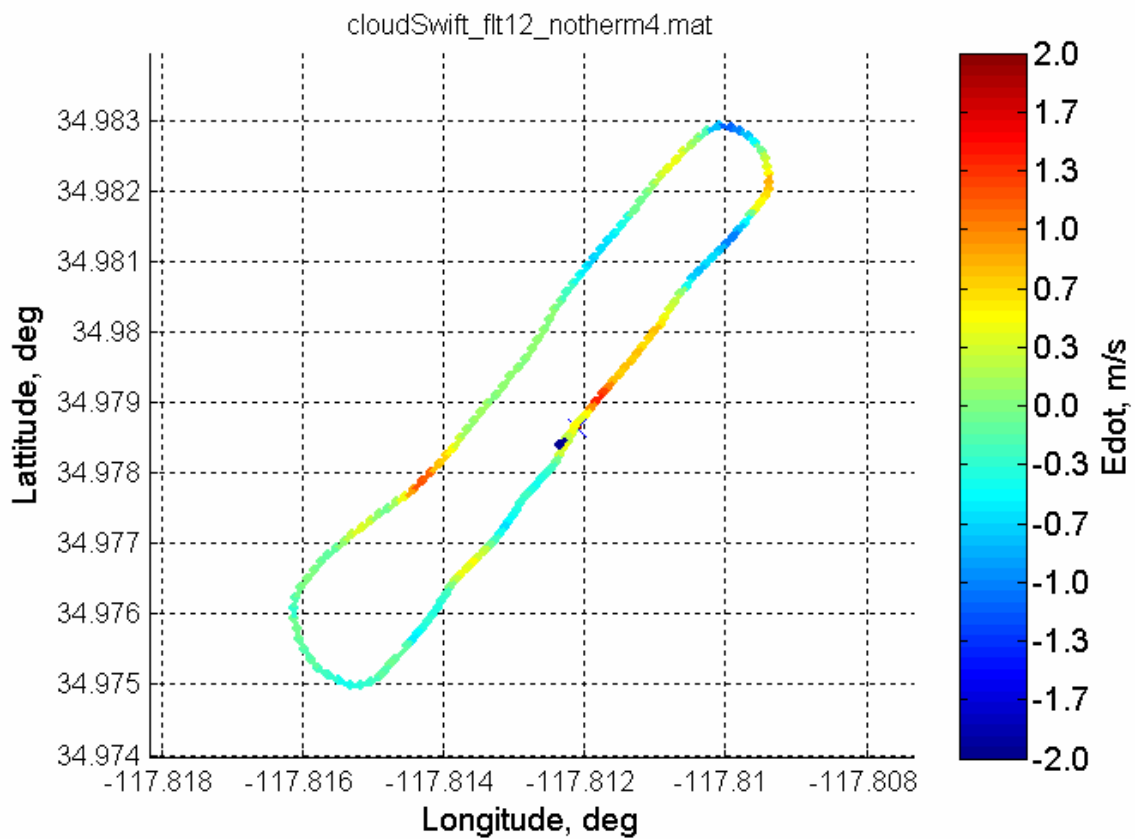


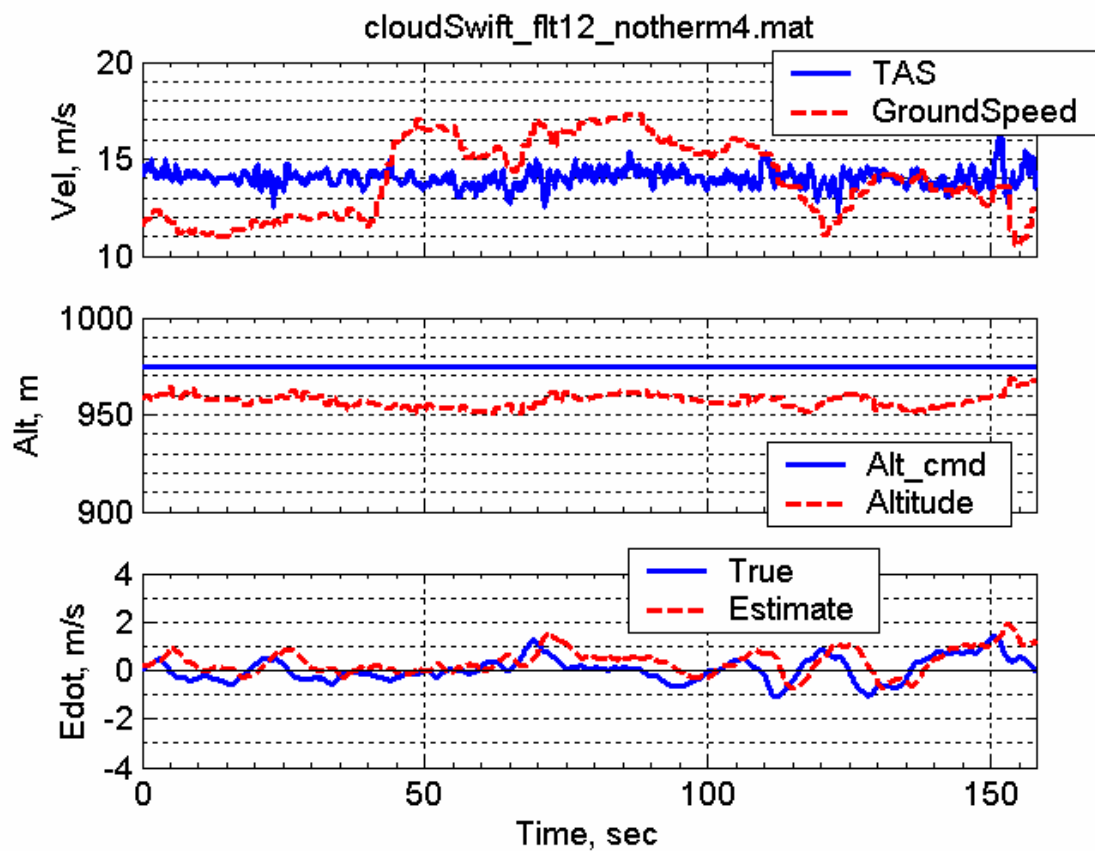
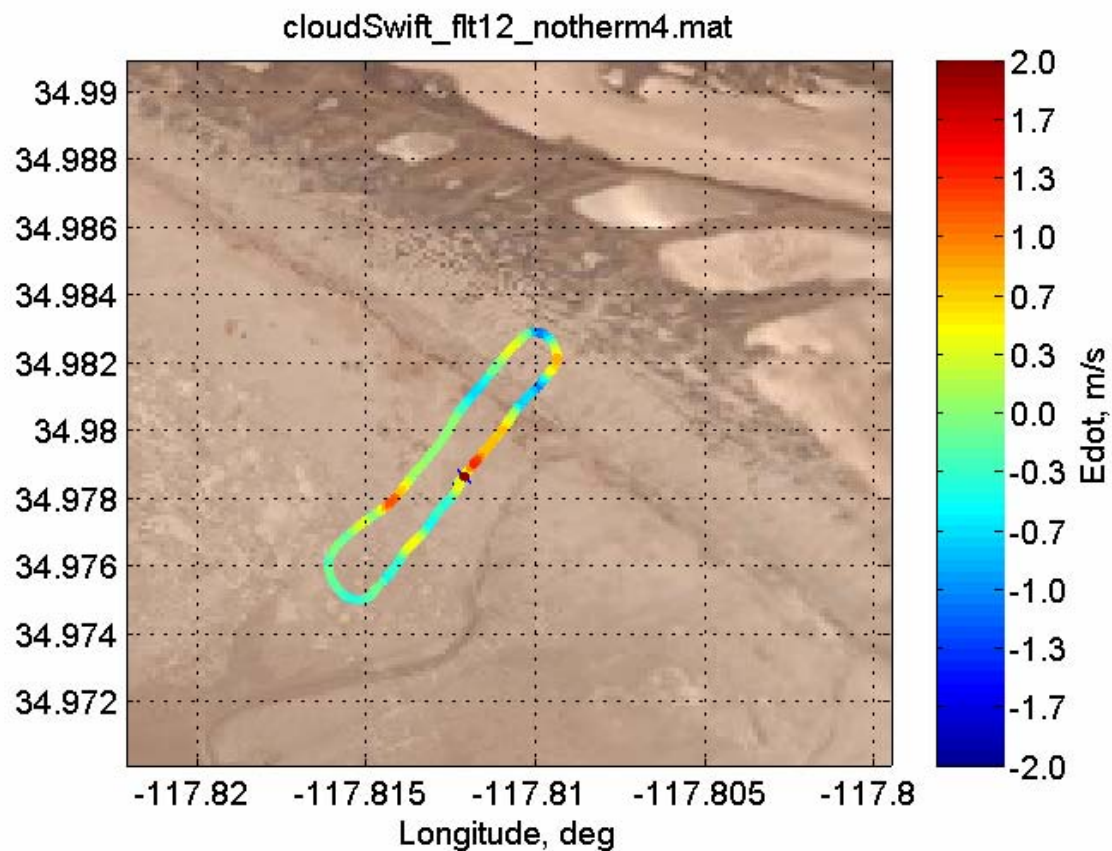


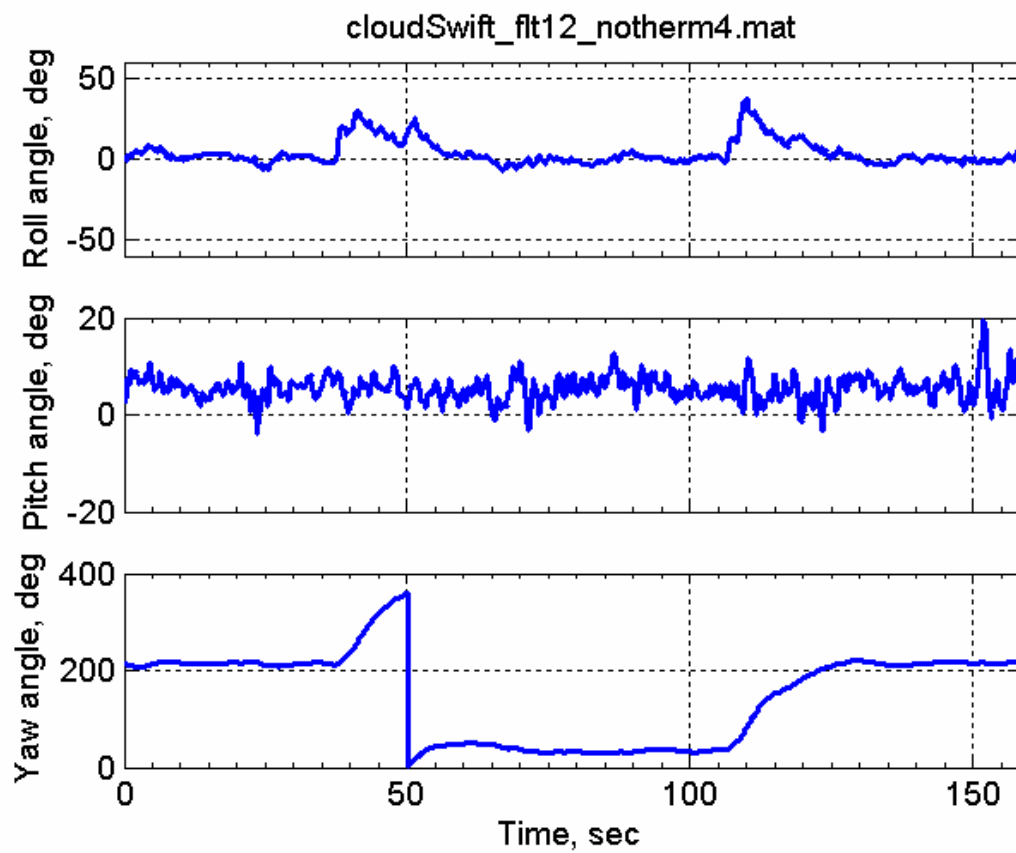
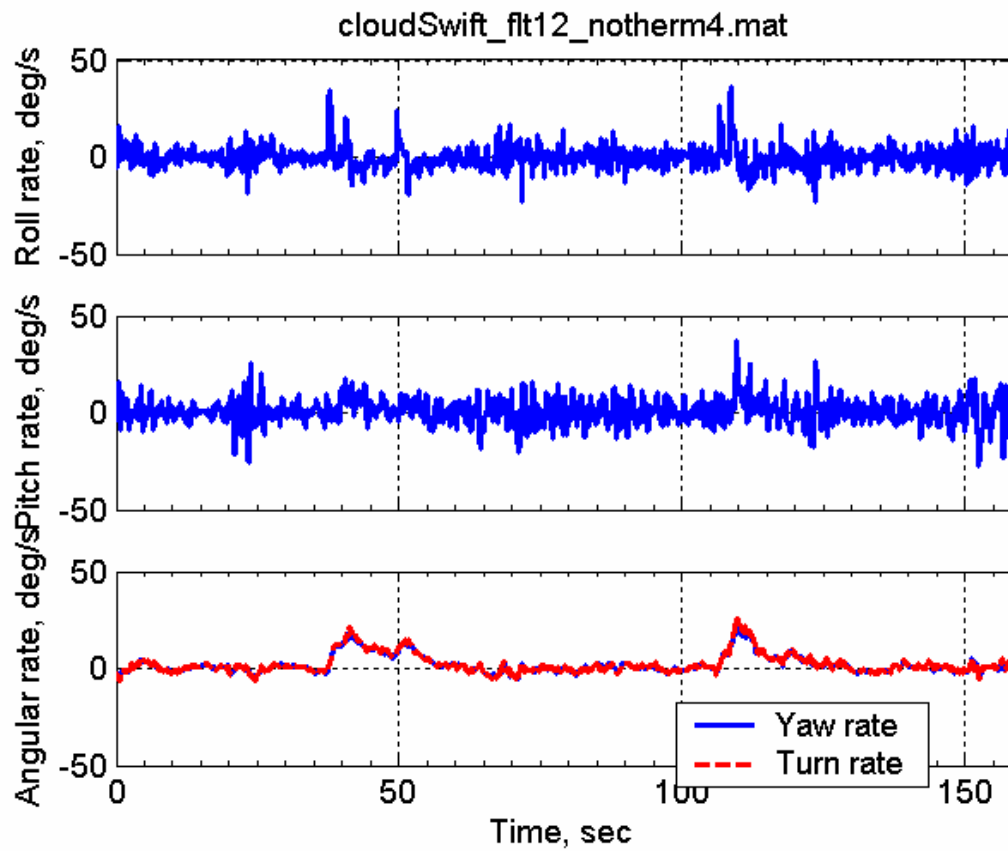


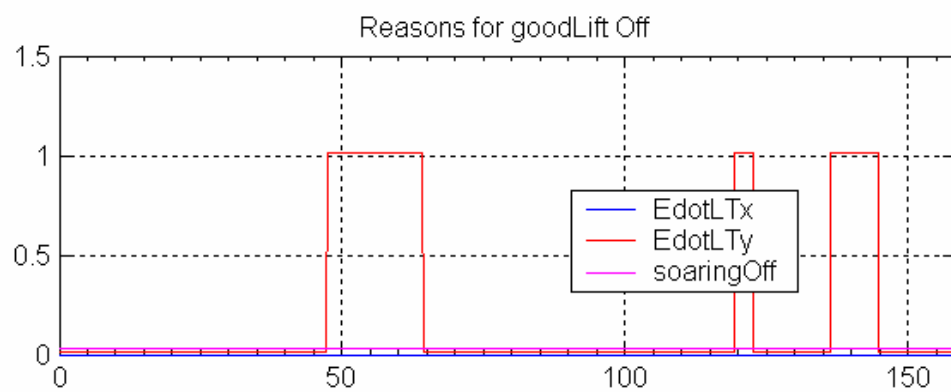
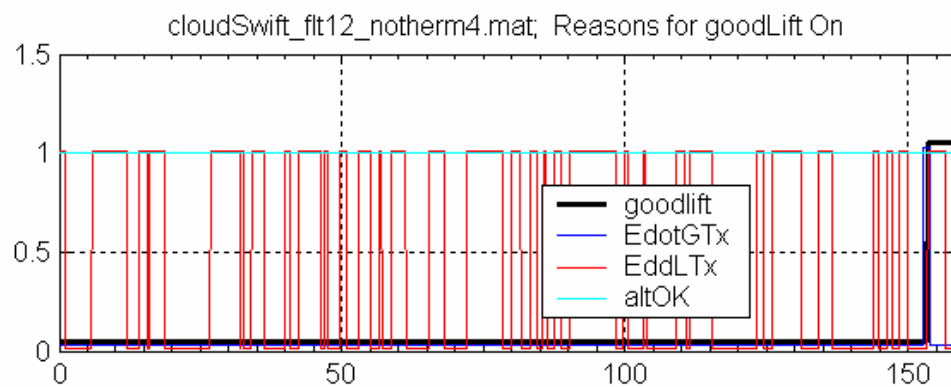
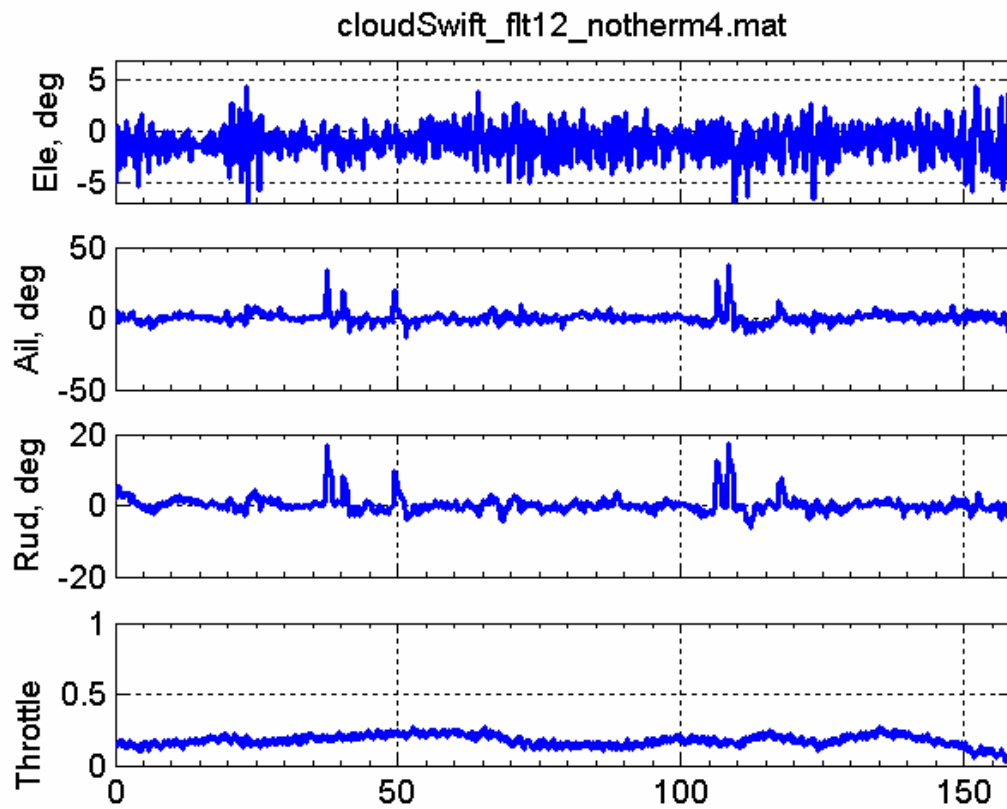
Flight 12, no thermals 4

Replay of flight data through Simulink shows that the soaring mode should have come on at the end of this section. Need to check to see if soaring was disabled by ground-station operator.



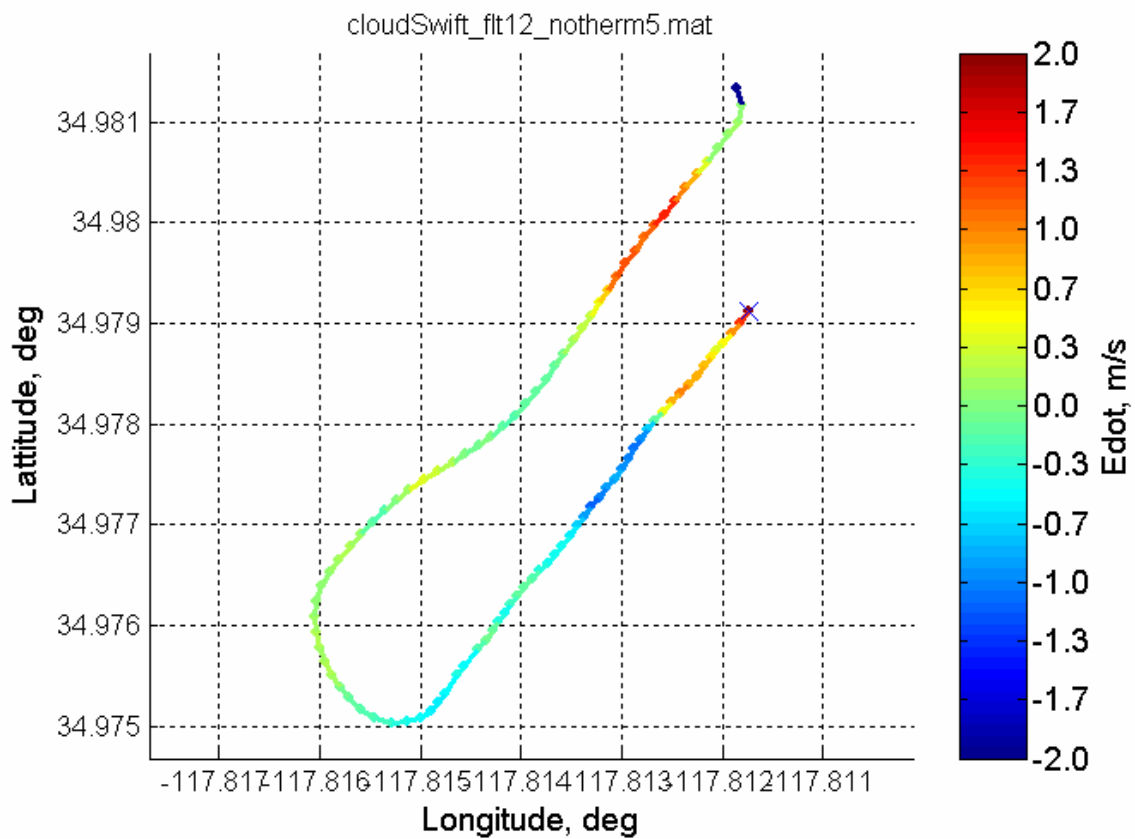


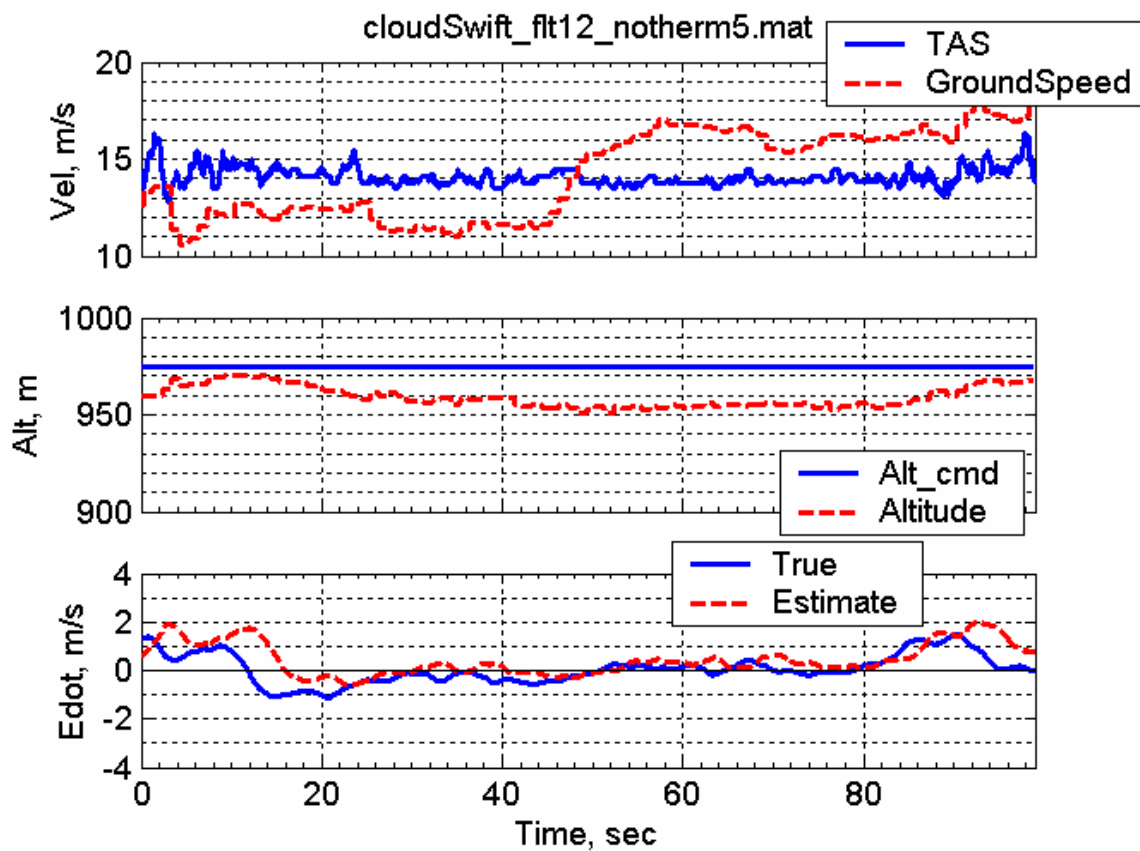
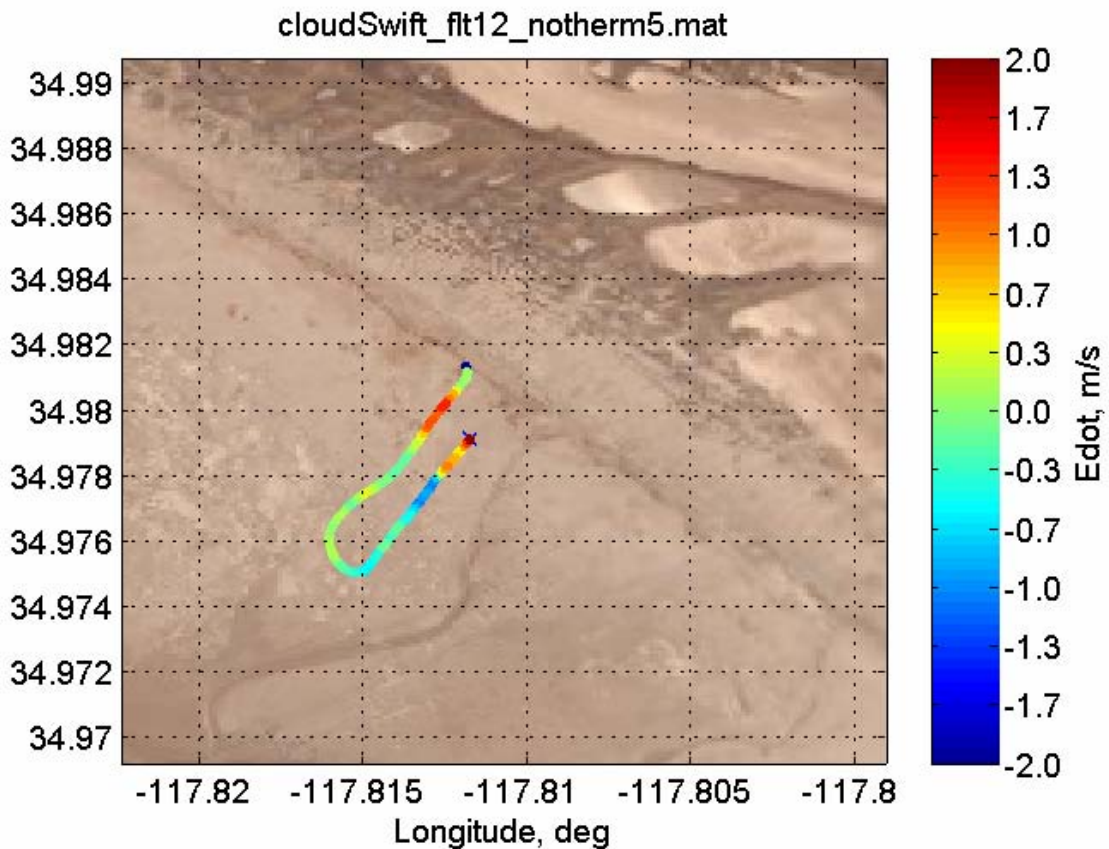


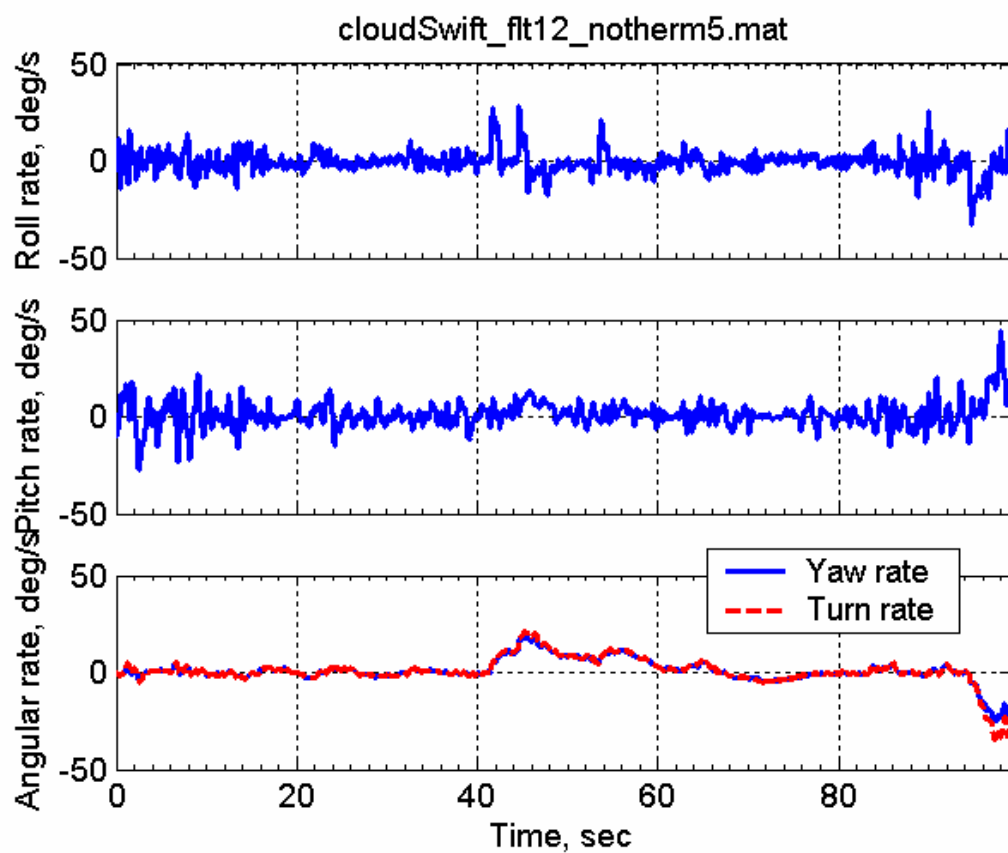


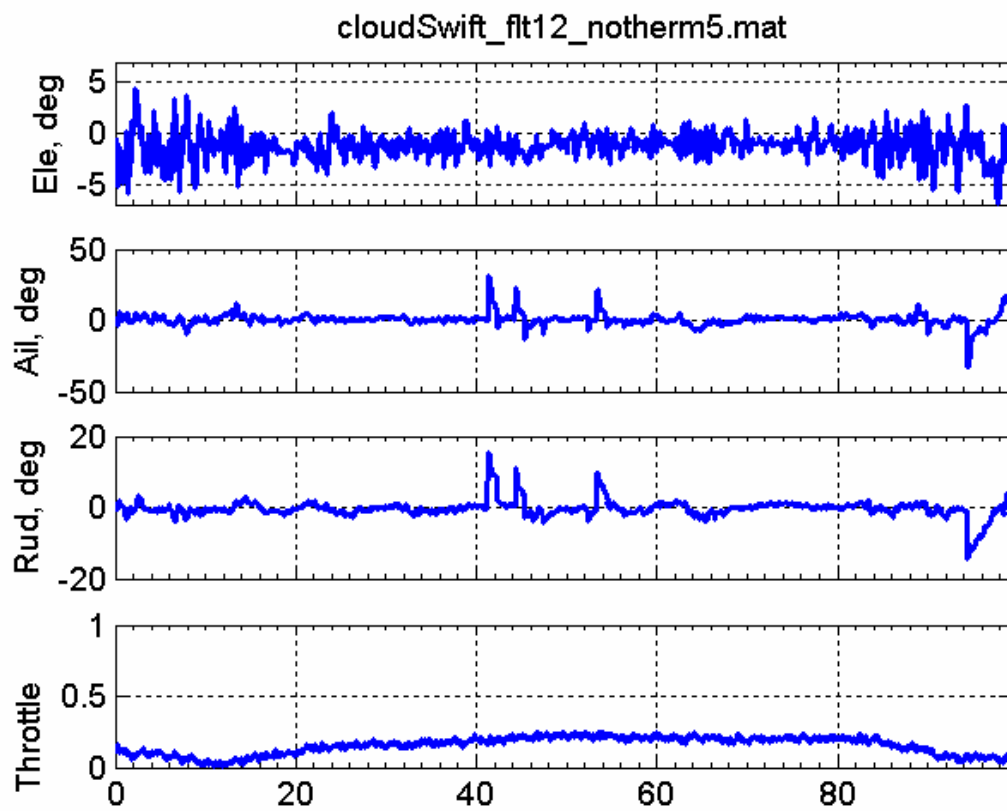
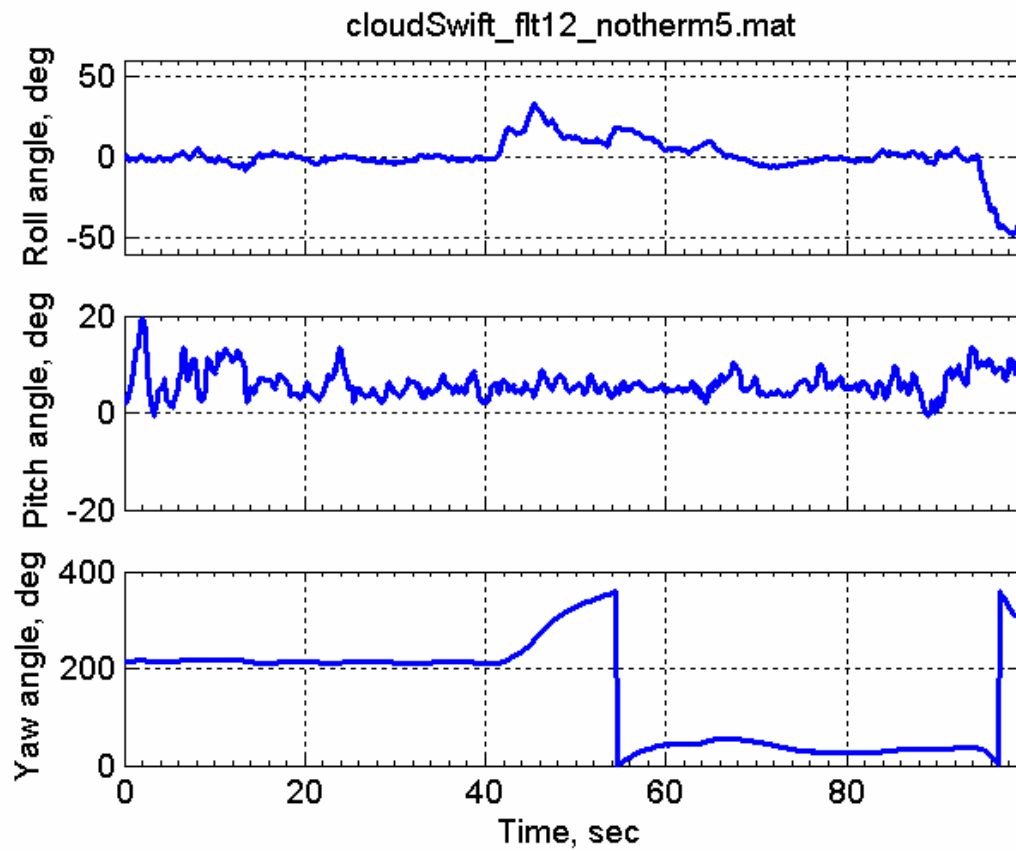
Flight 12, no thermals 5

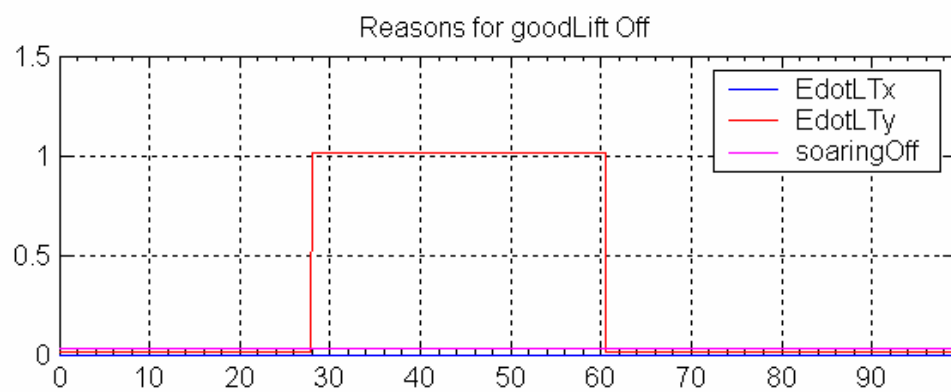
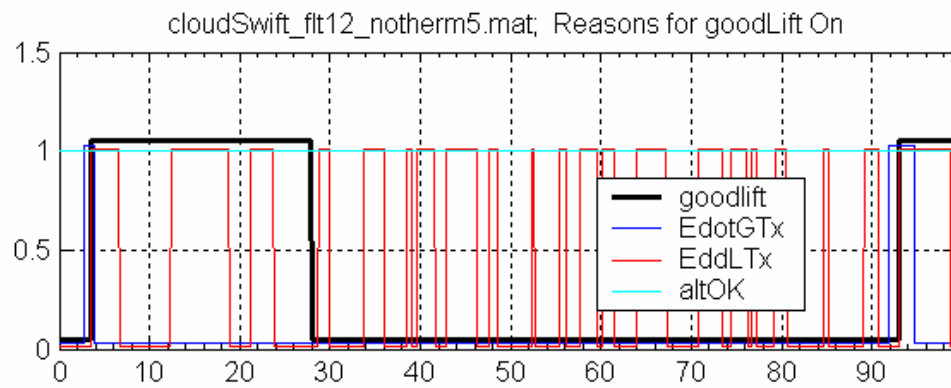
Again the replay of flight data shows that soaring mode should have tripped on. Was soaring disabled by the ground station operator? Need to check .tel file.





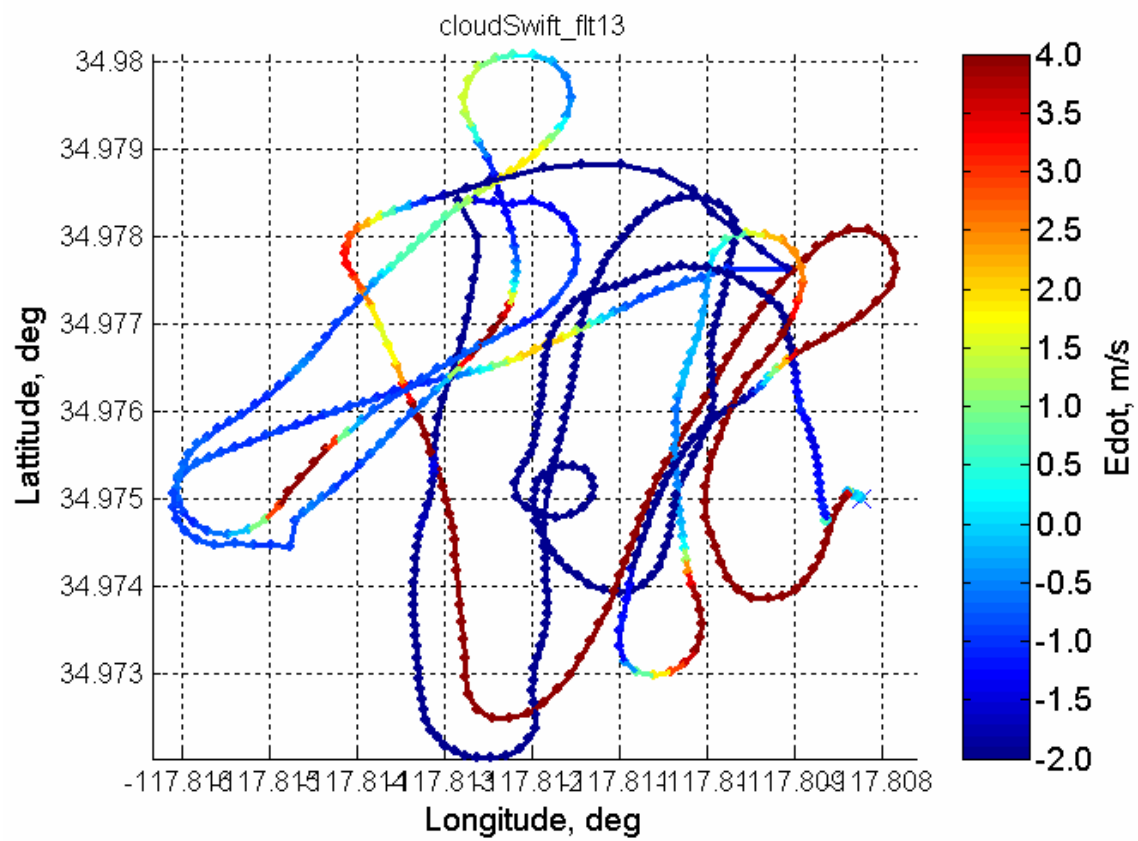


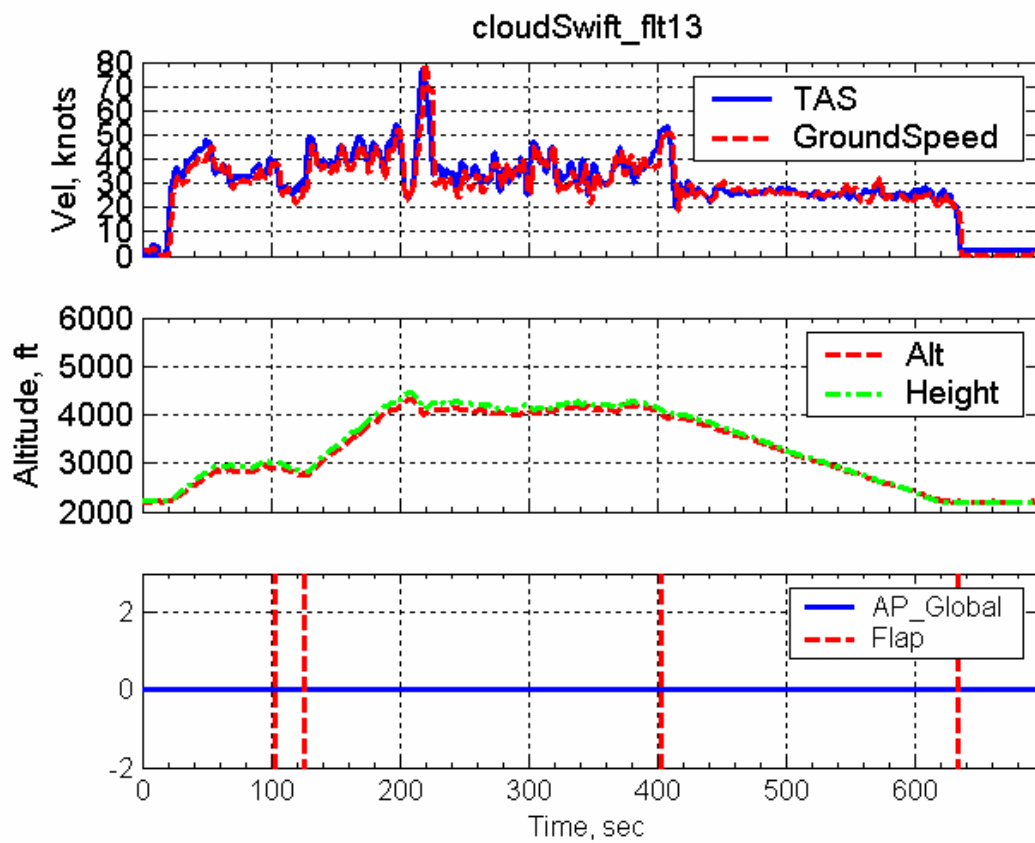
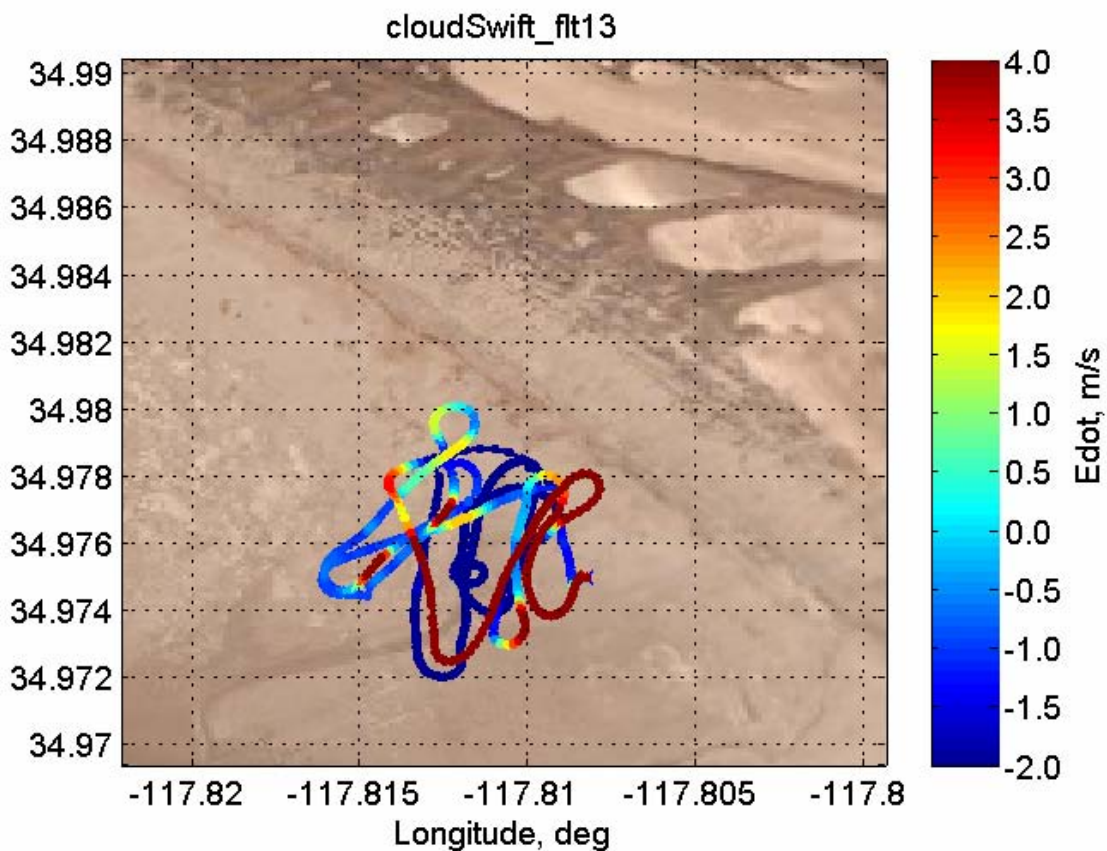


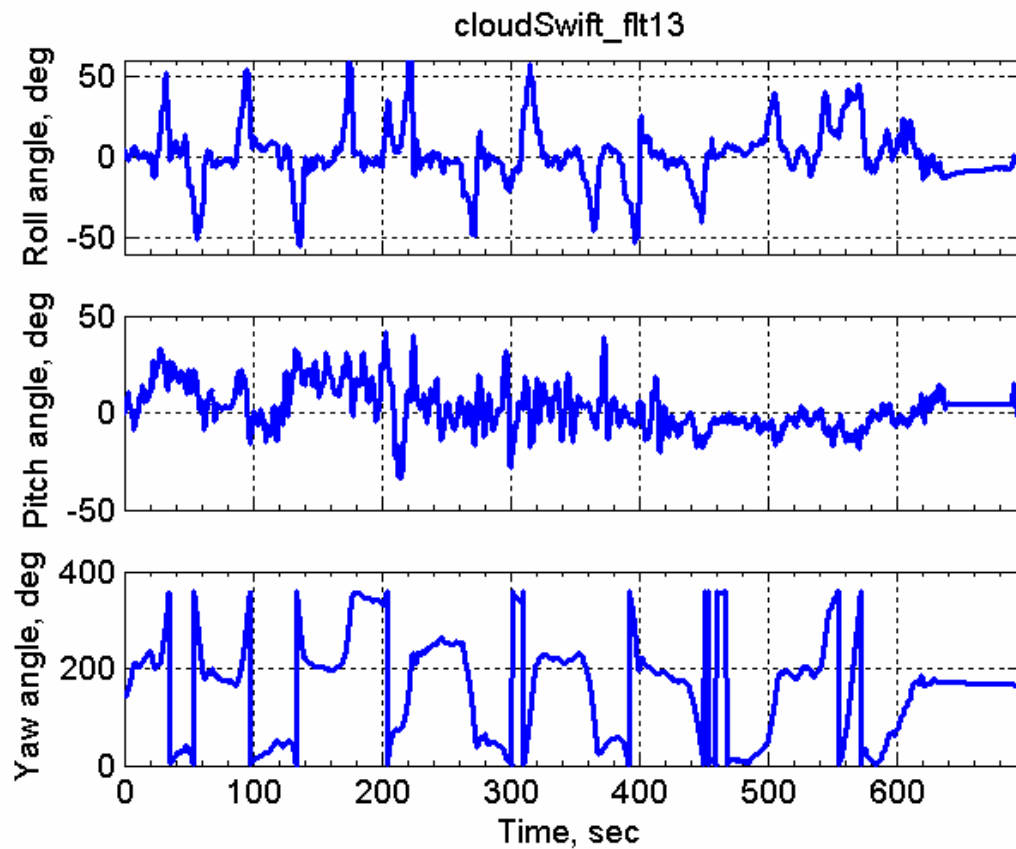
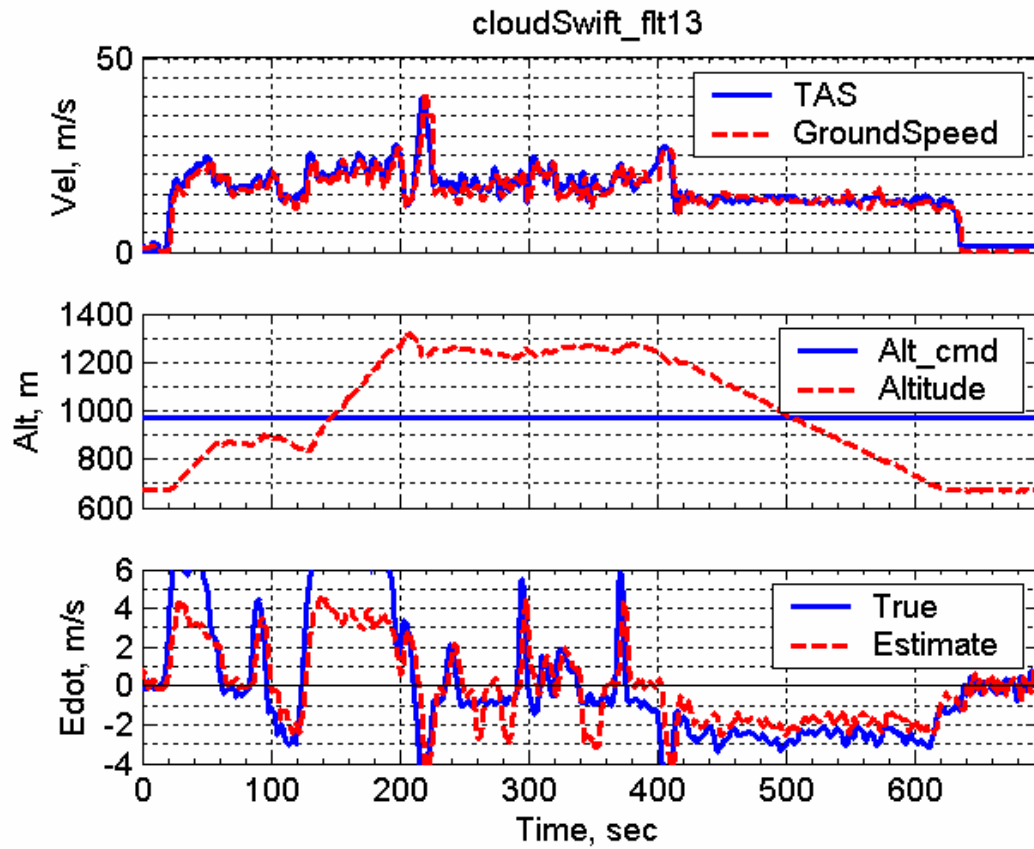


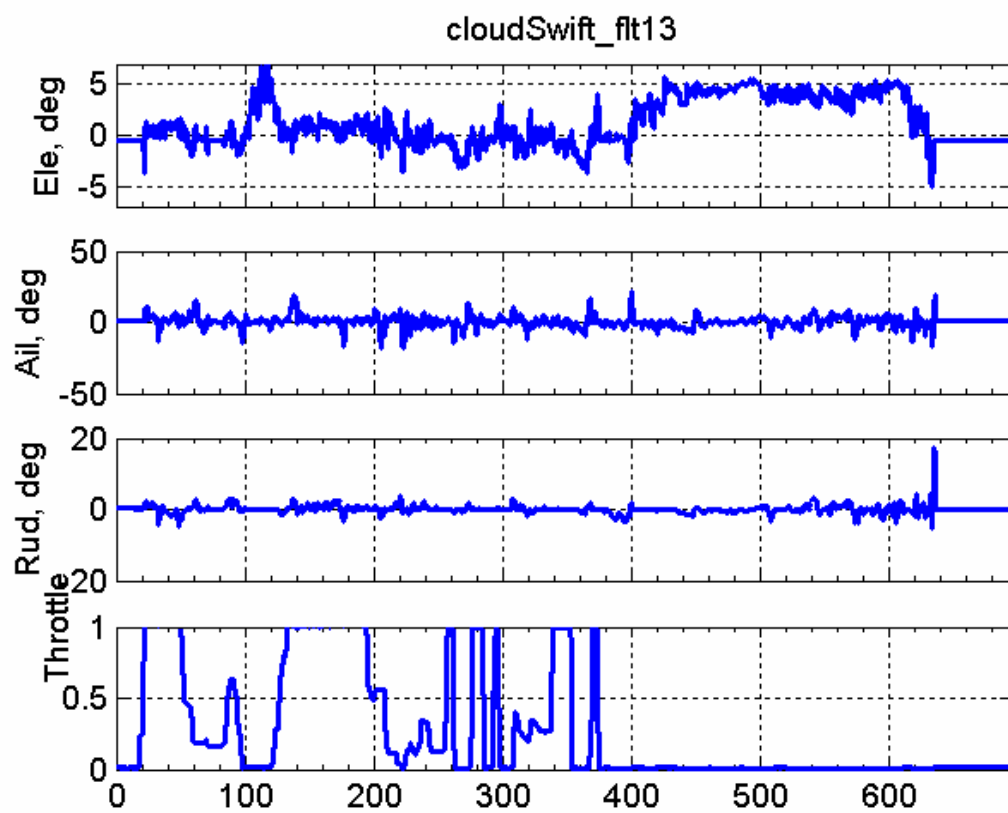
Flight 13

Piloted check flight for FTS test. Good continuous climb and flaps-on descent.



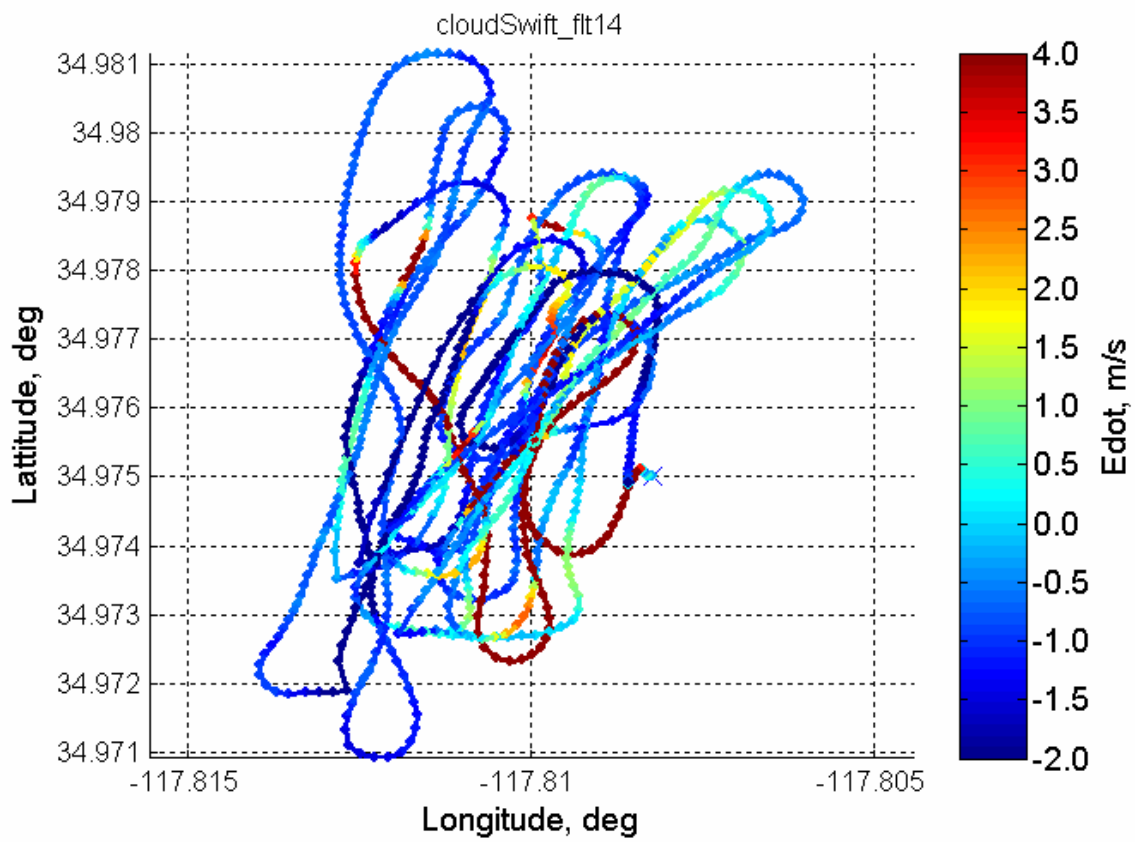


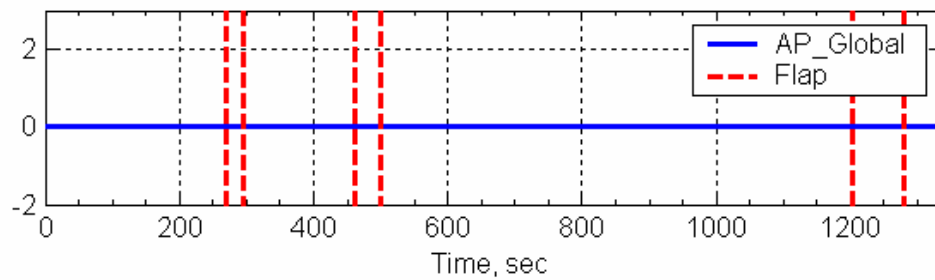
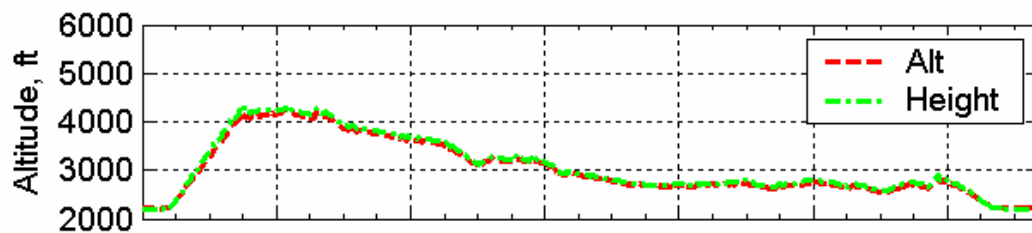
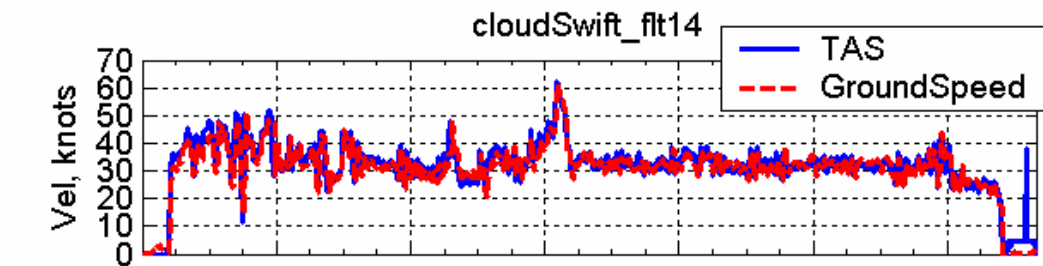
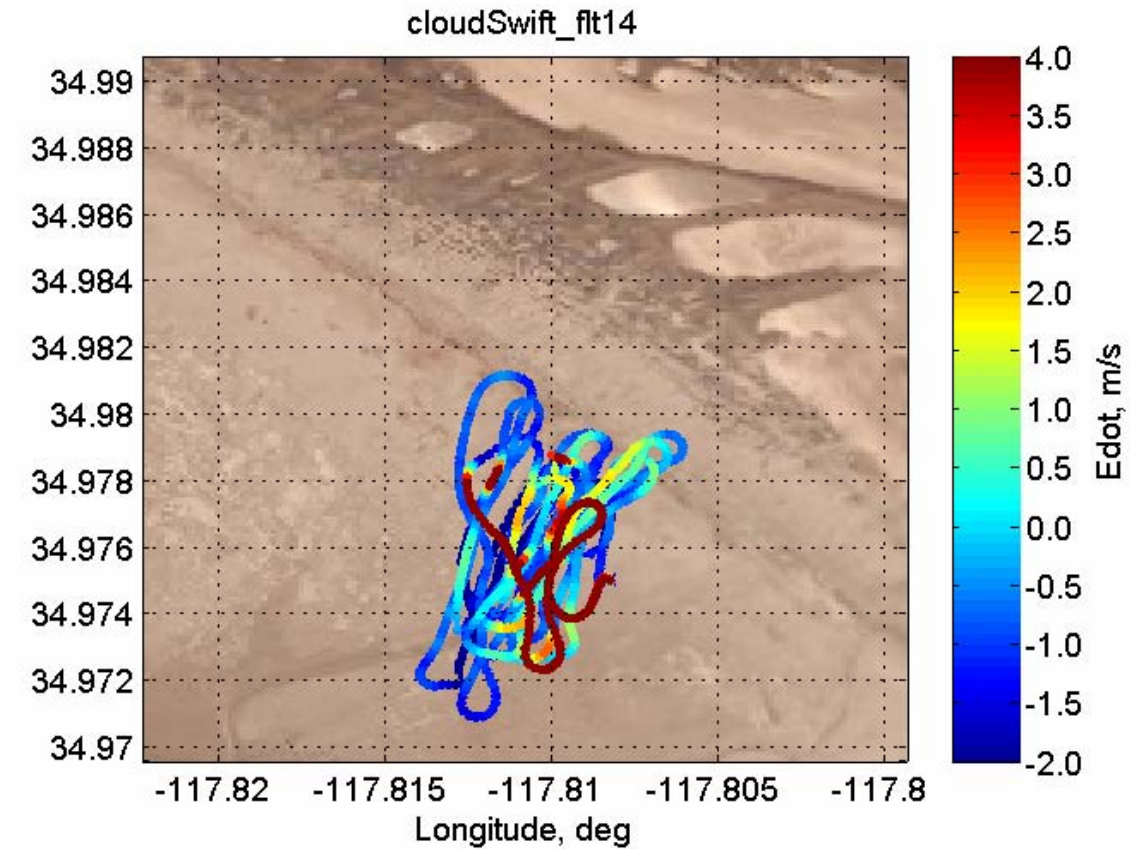


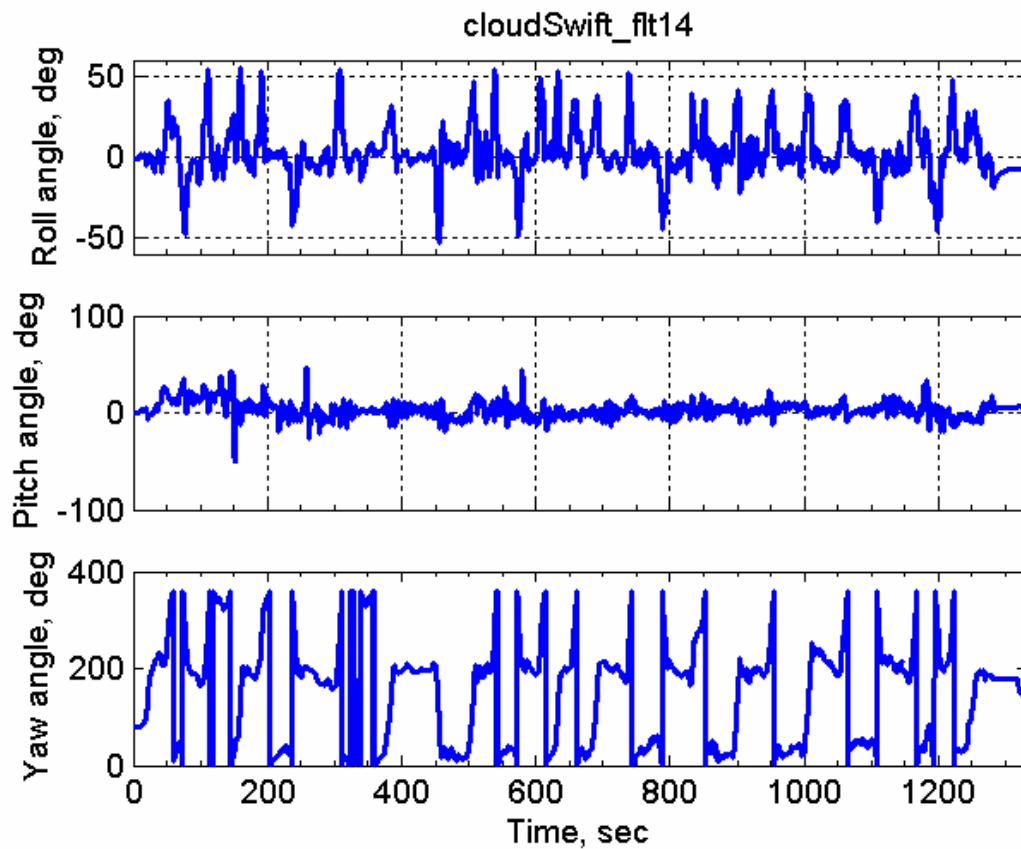
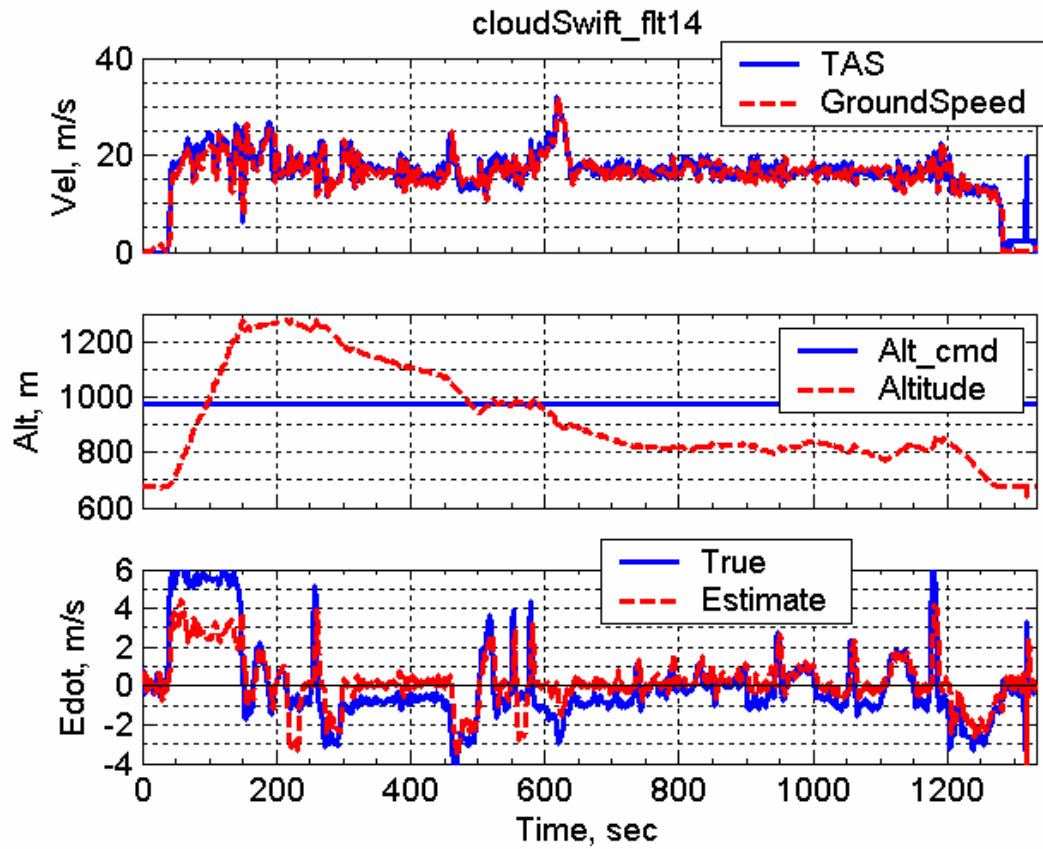


Flight 14

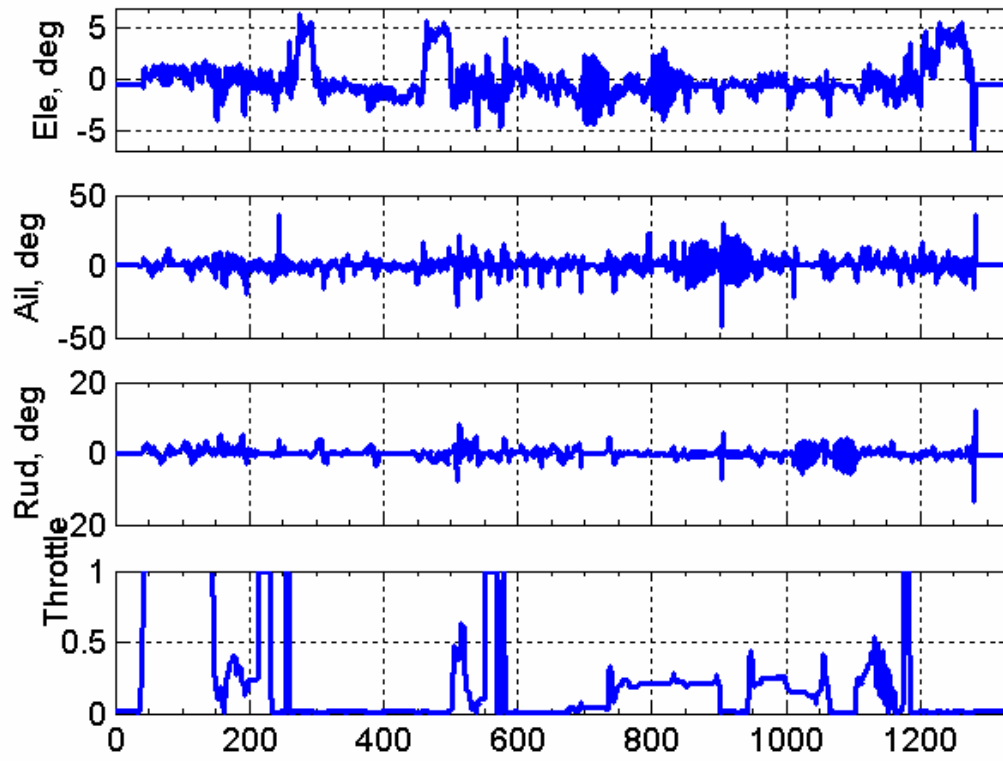
FTS range test. Pilot also did control surface sweeps with power on and power off.





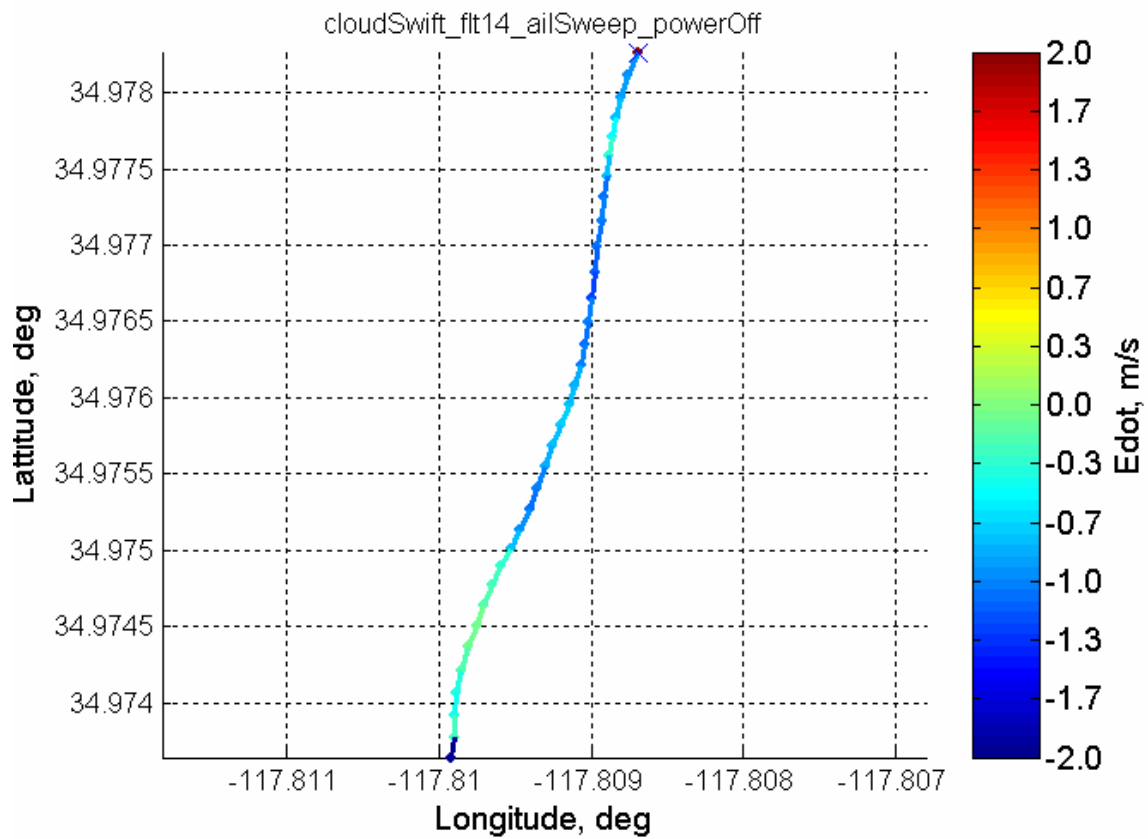


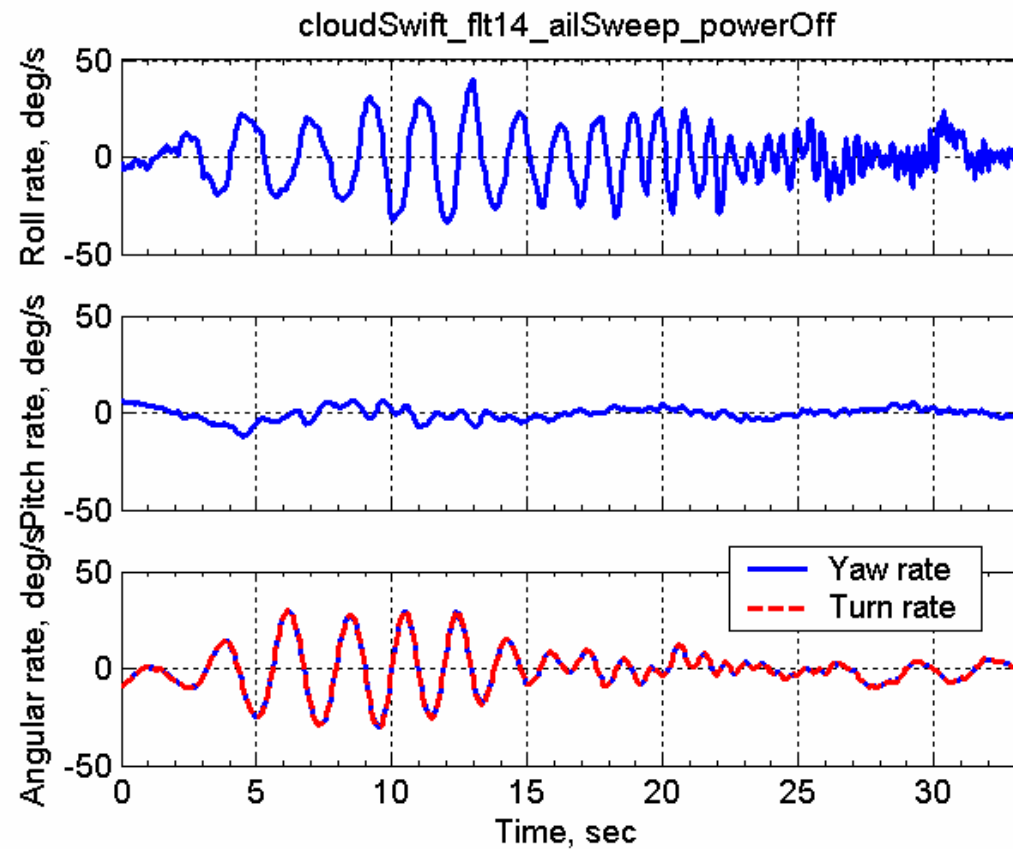
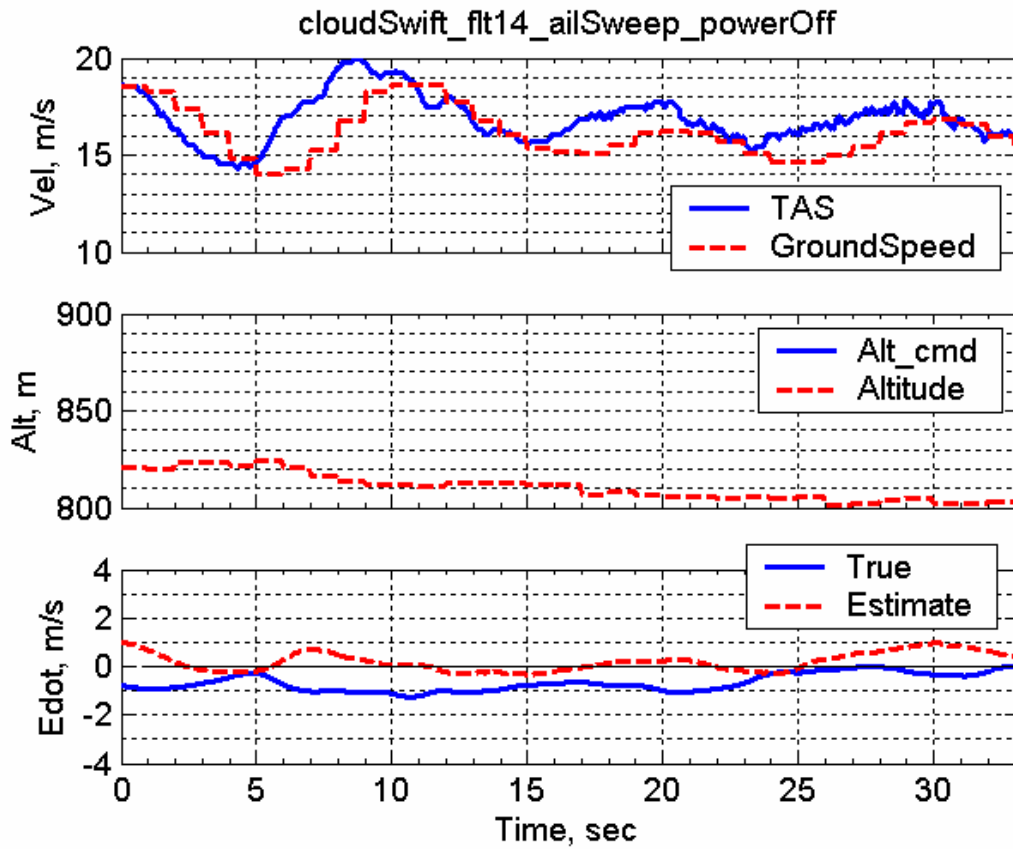
cloudSwift_ft14

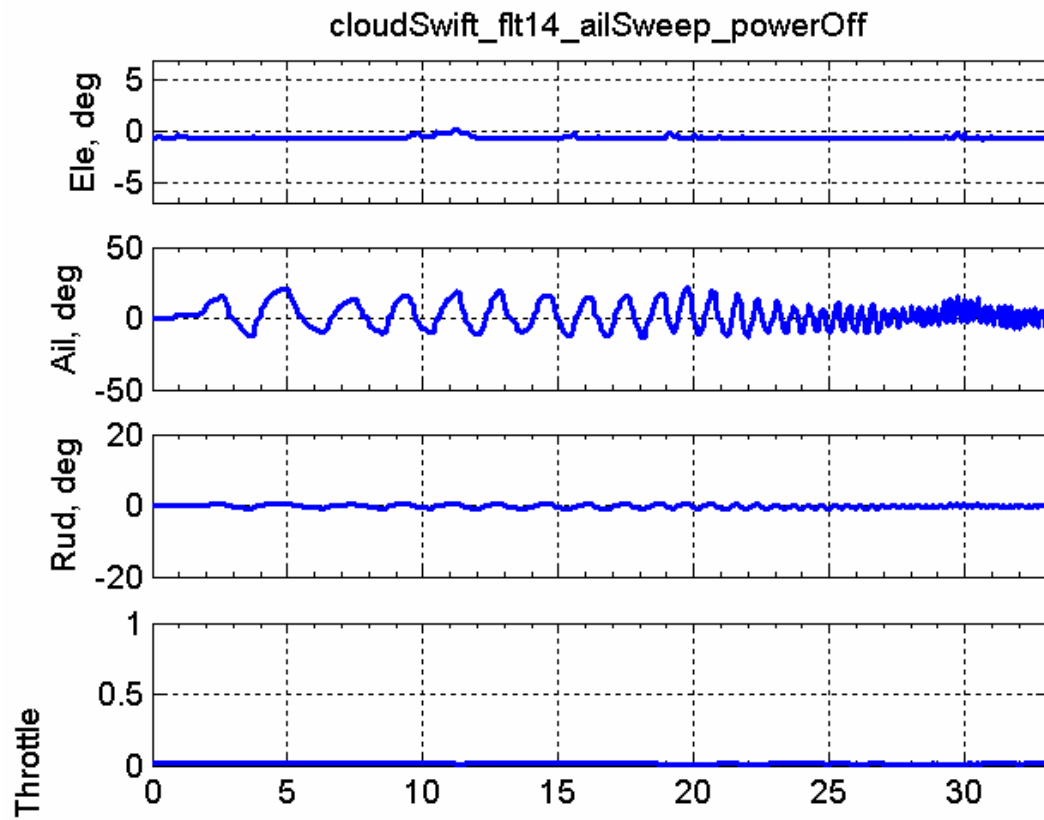
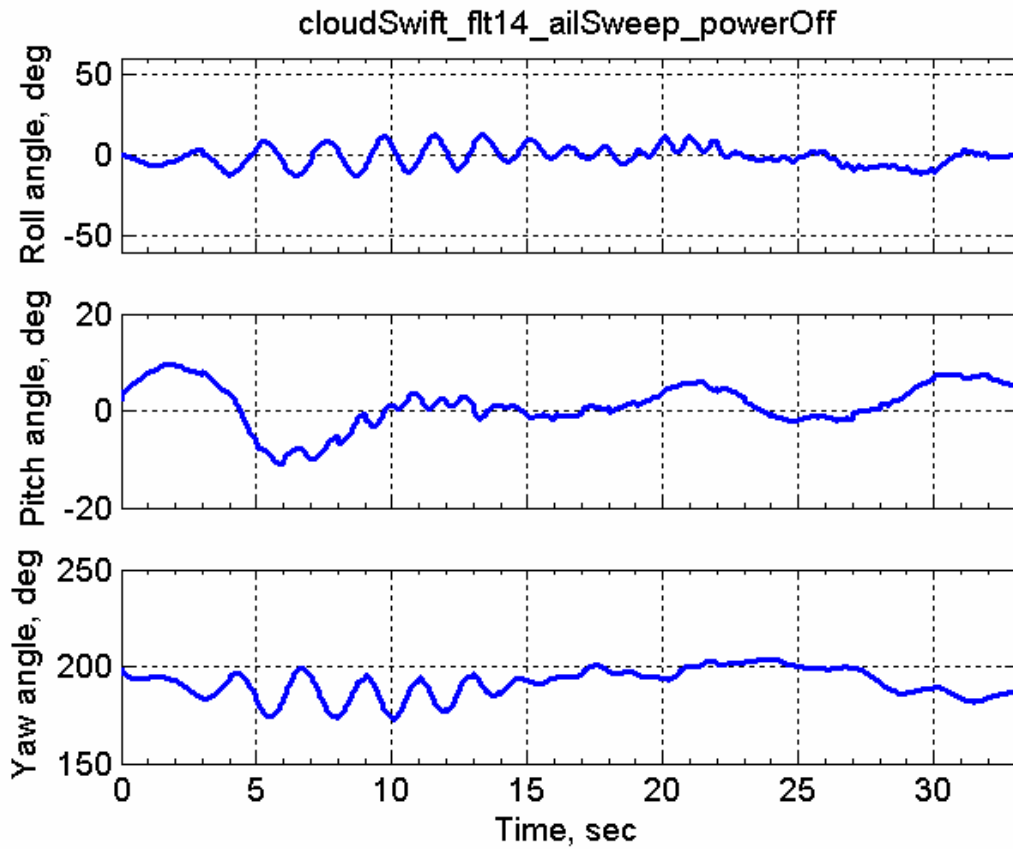


Flight 14, Aileron Sweep, Power Off

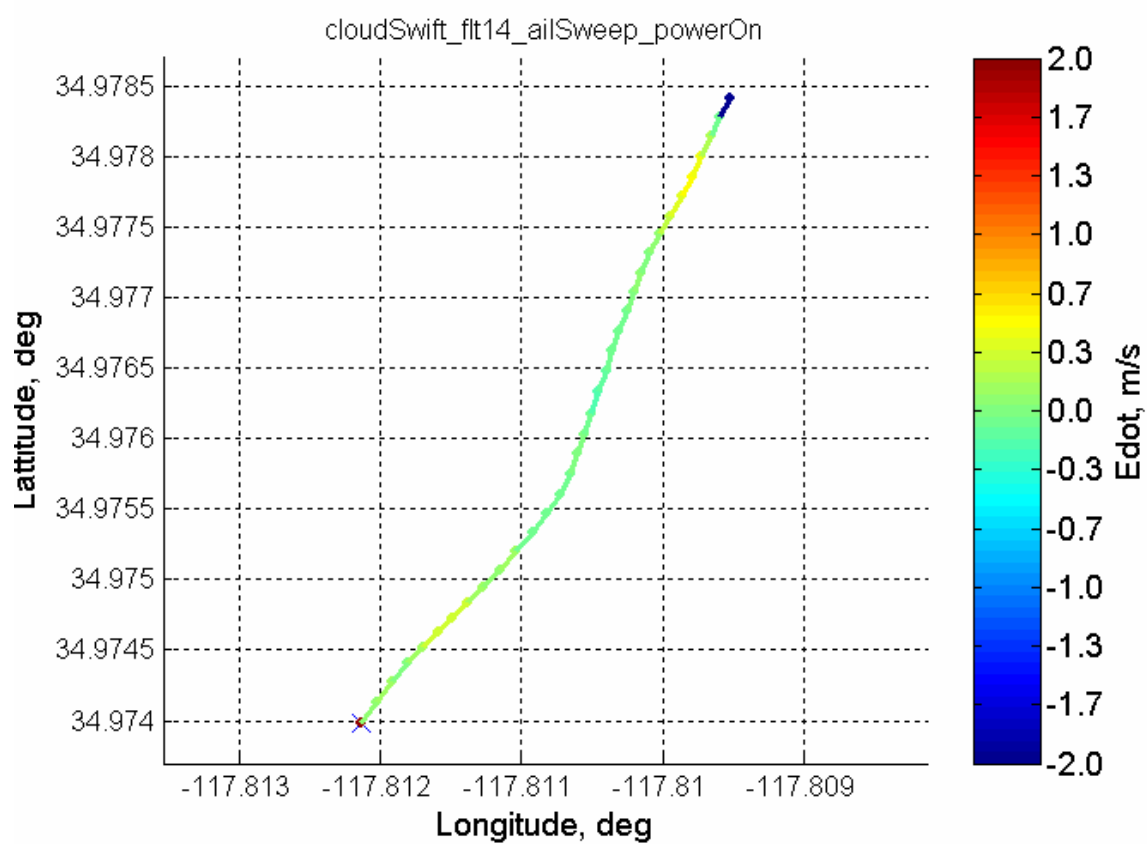
Piloted aileron sweep. Note the aileron to rudder coupling.

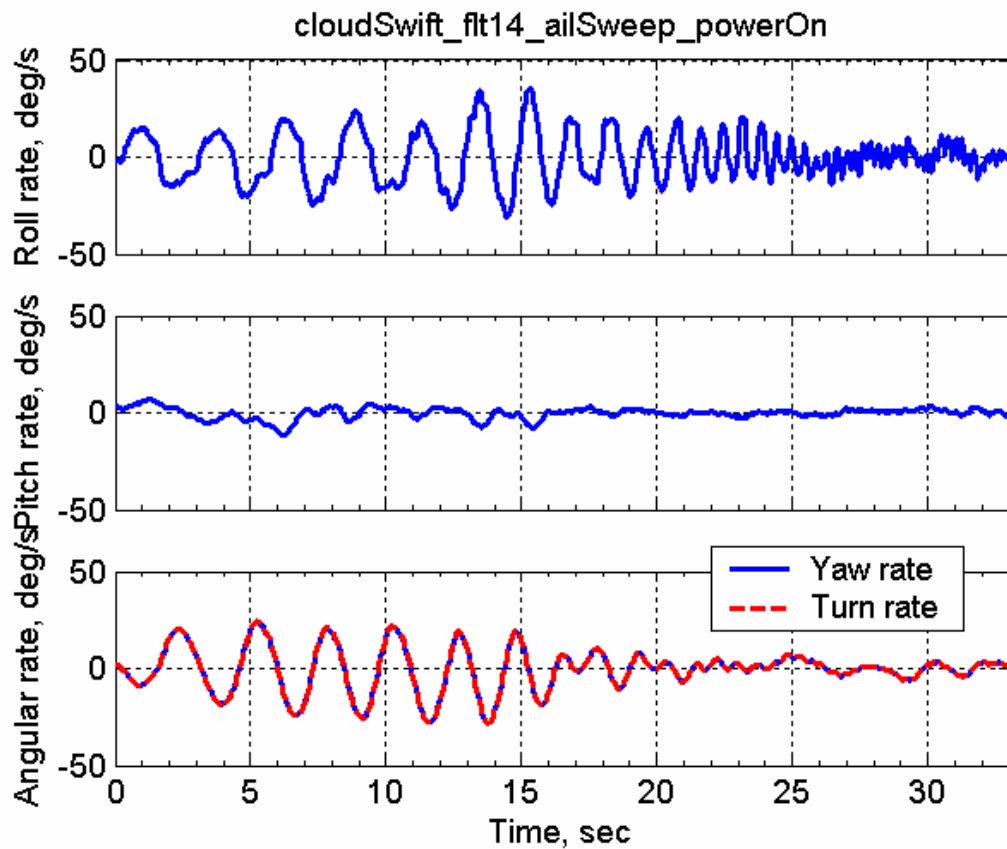
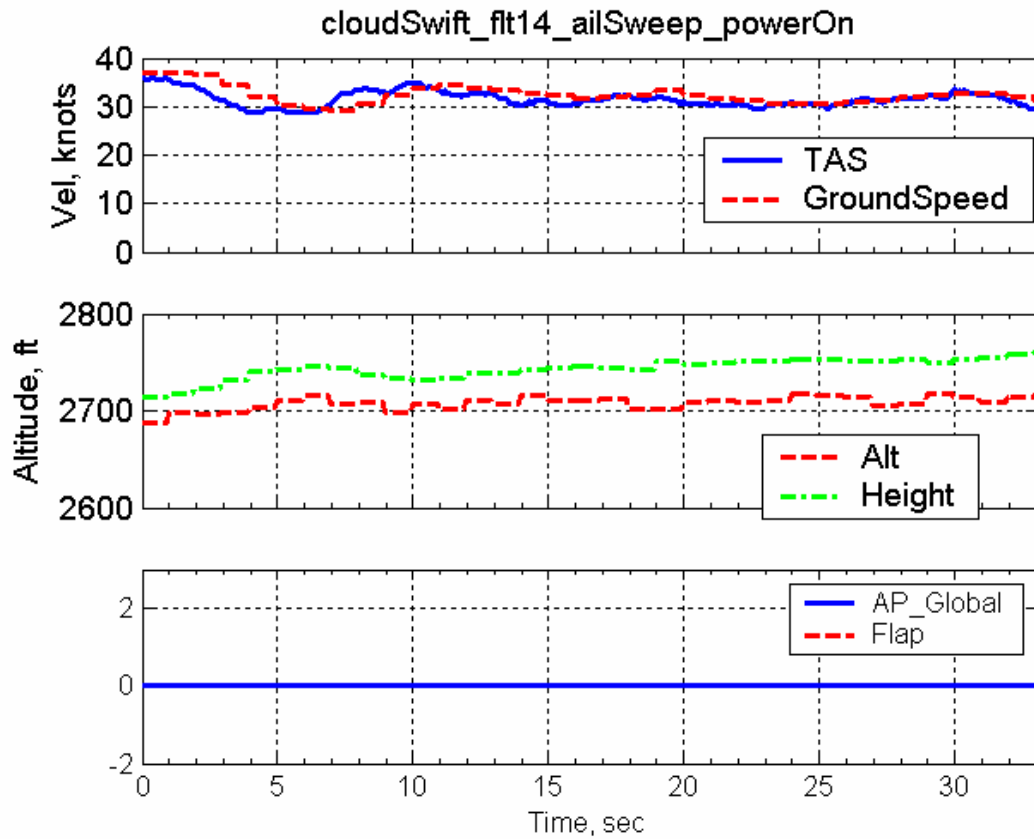


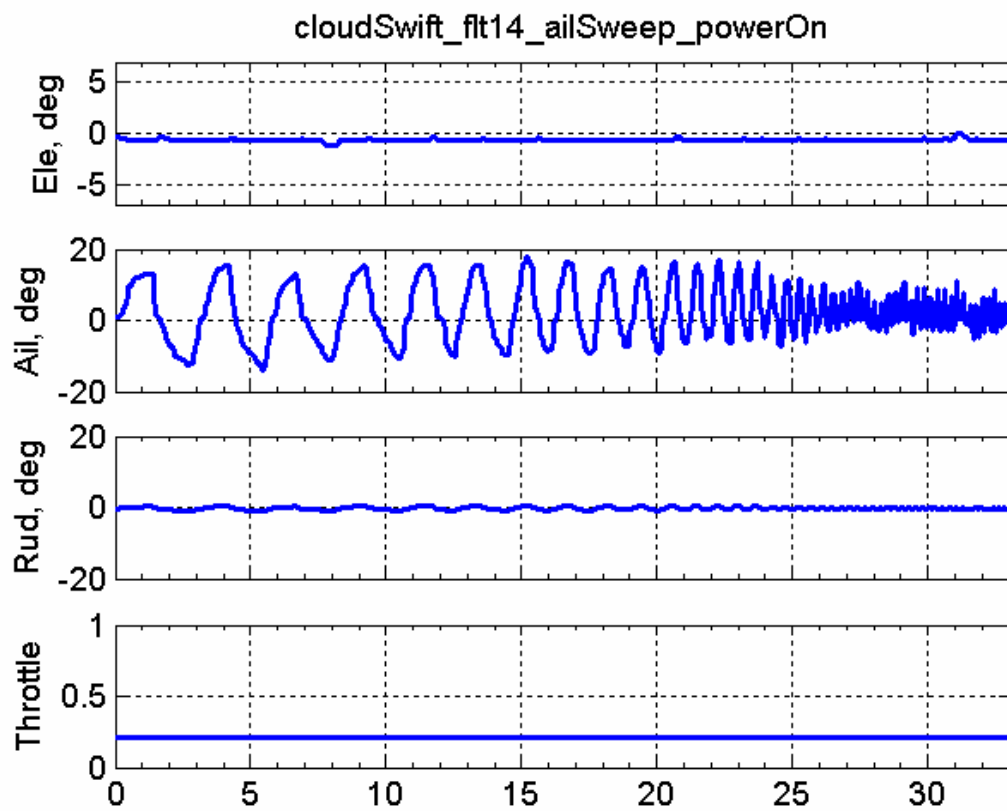
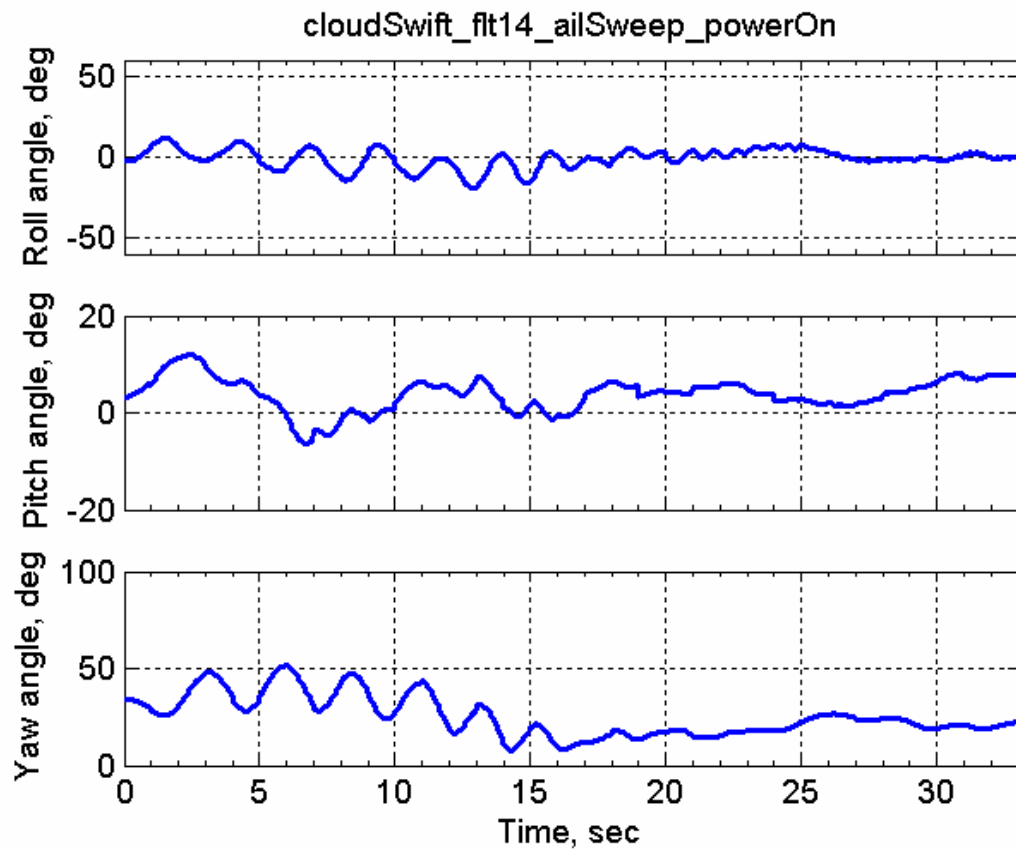




Flight 14, Aileron Sweep, Power On

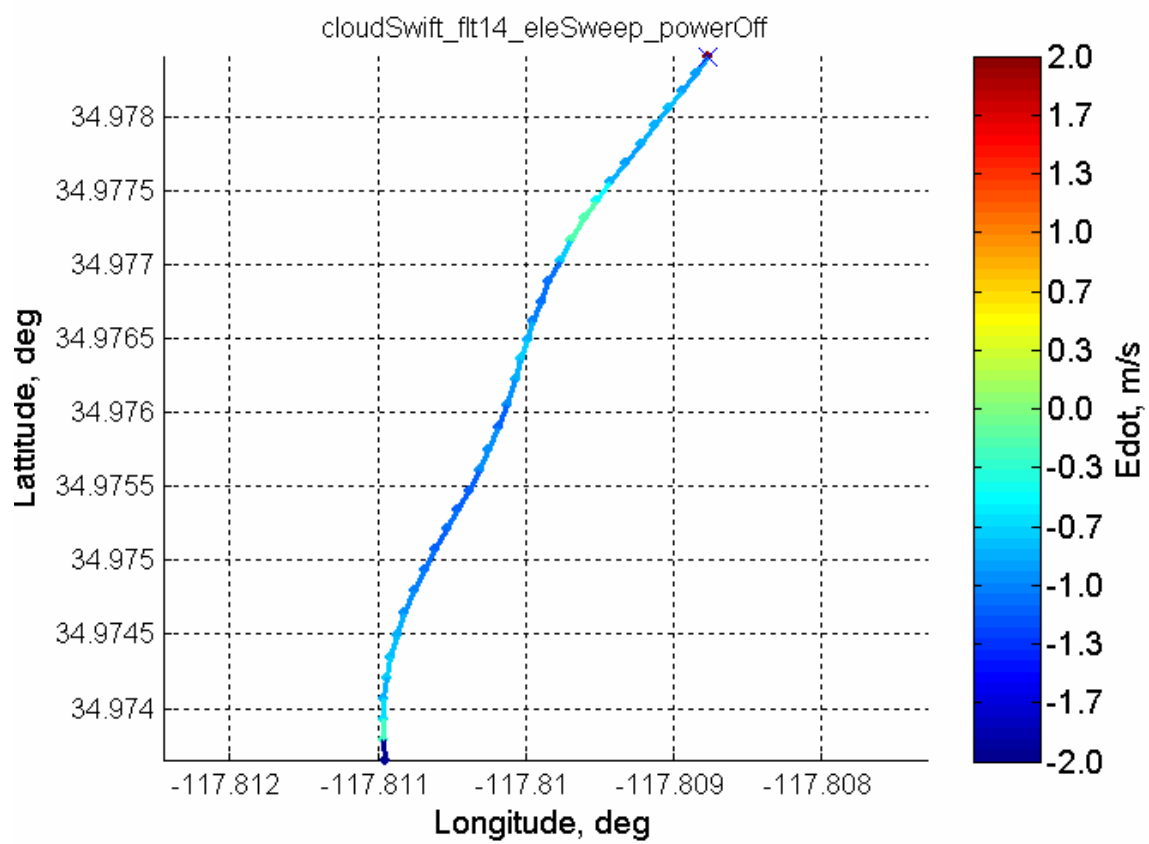


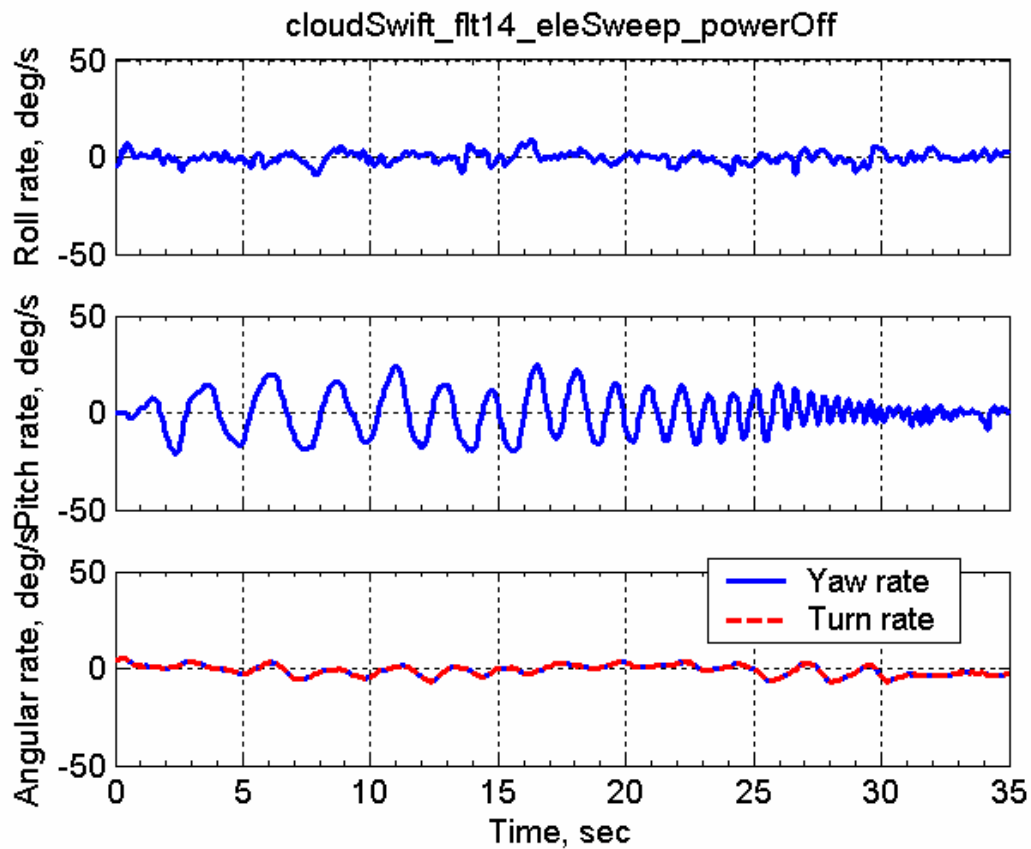
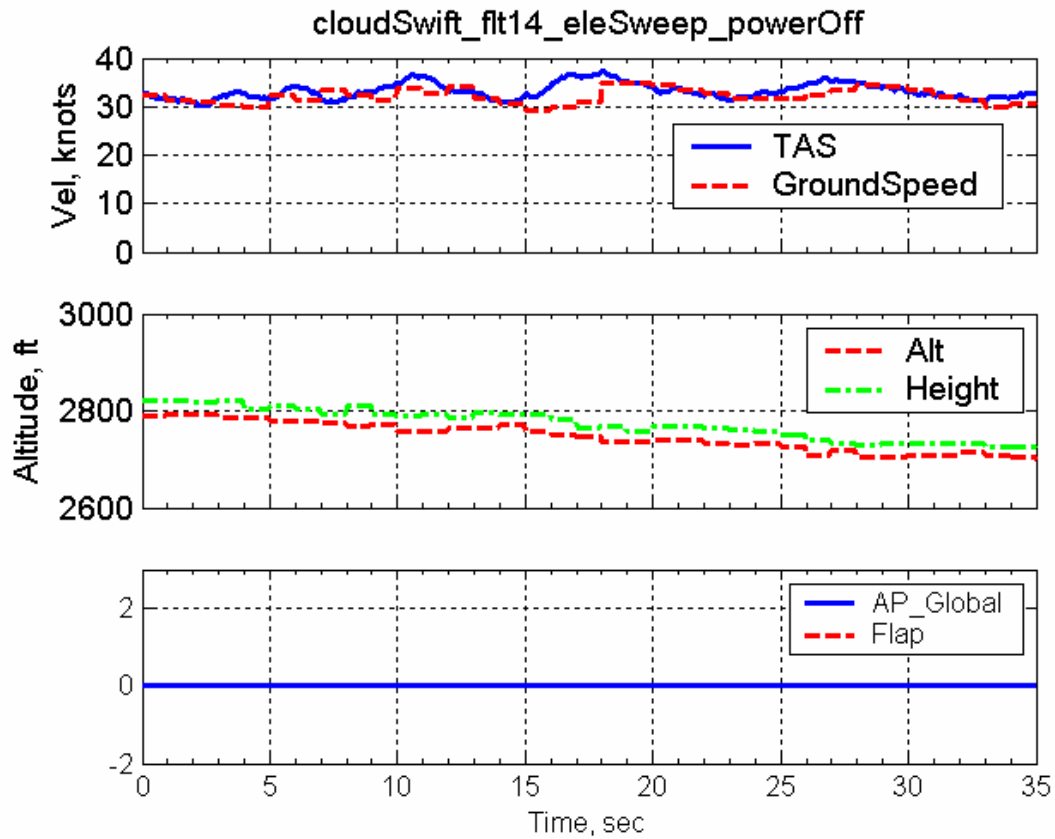


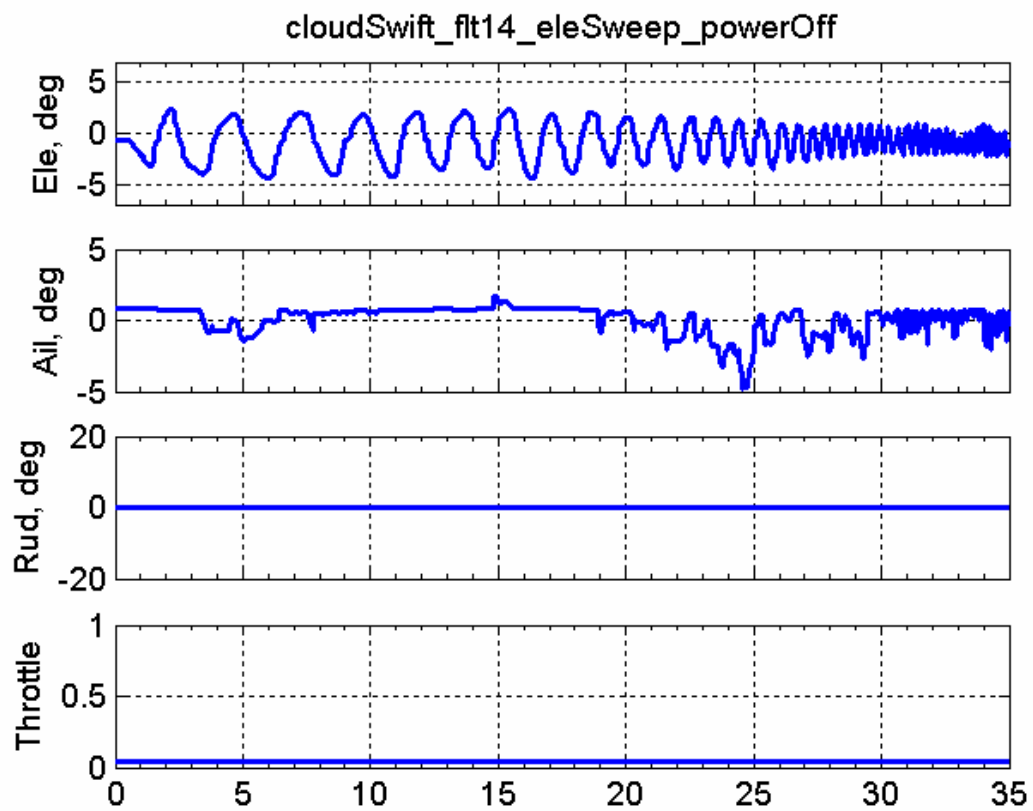
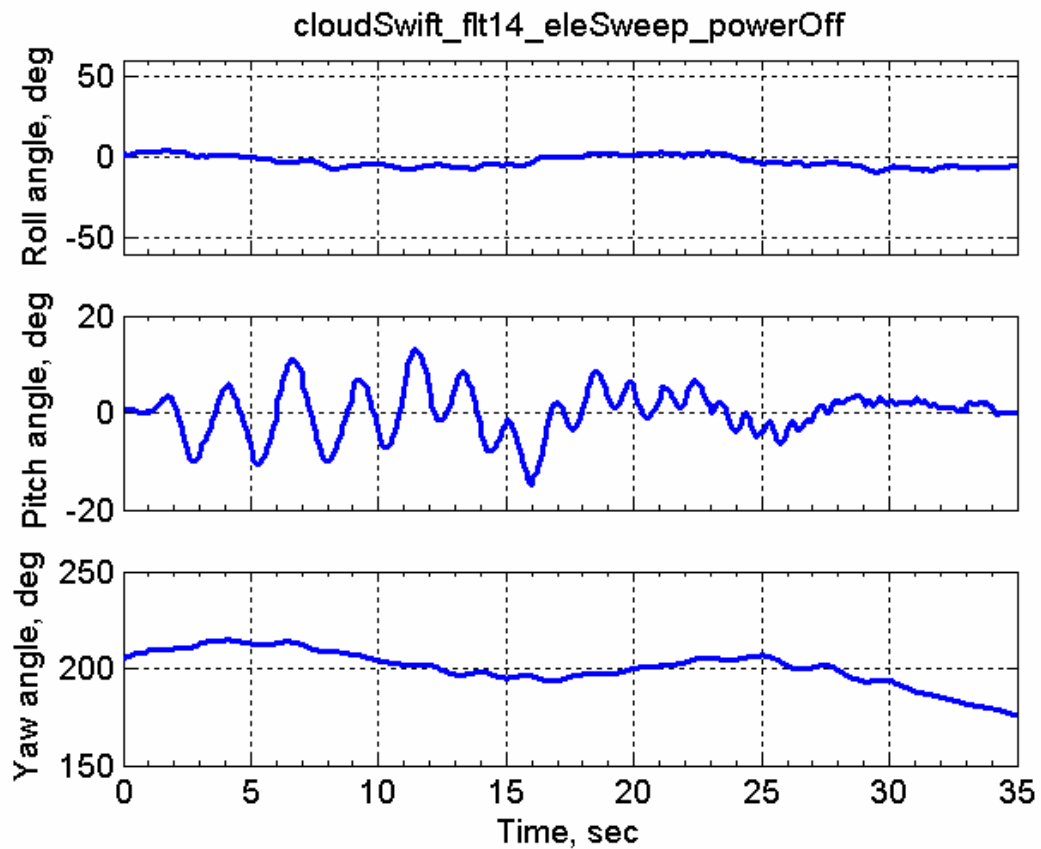


Flight 14, Elevator Sweep, Power Off

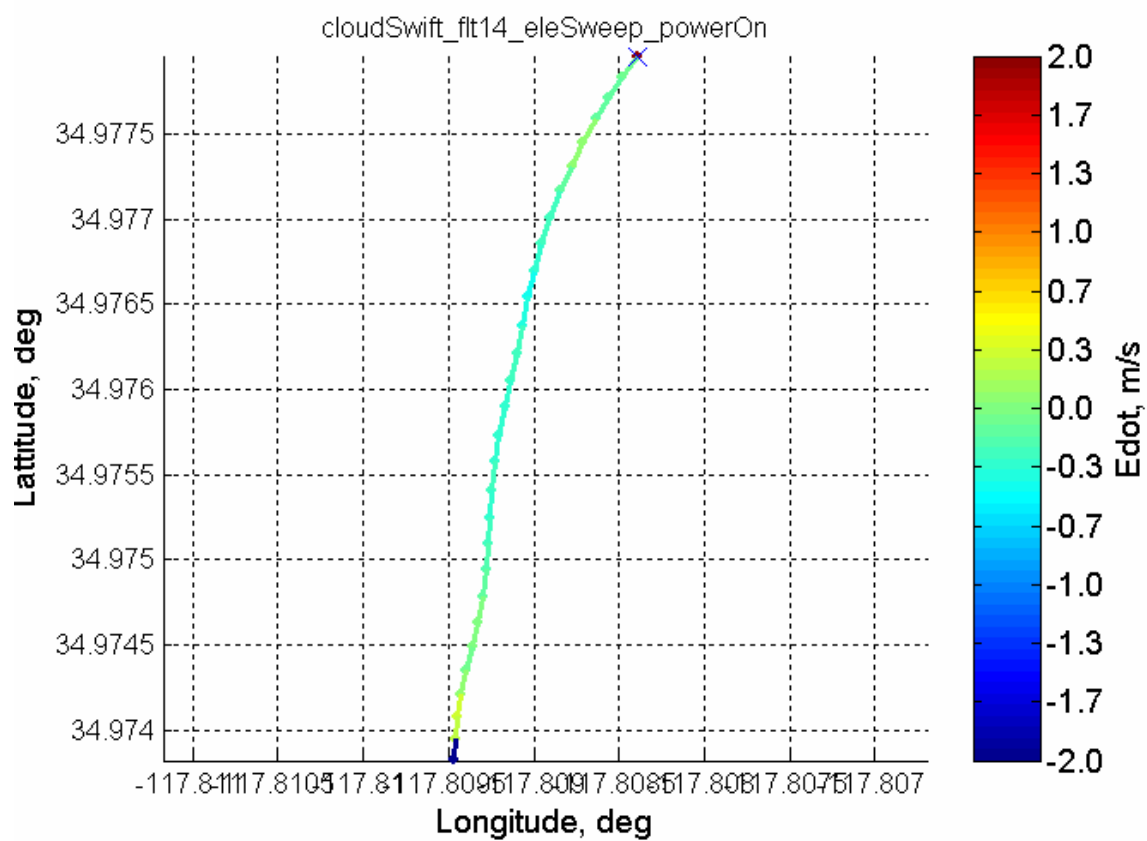
Some aileron stick movement at high frequency due to off-axis pilot stick movement.

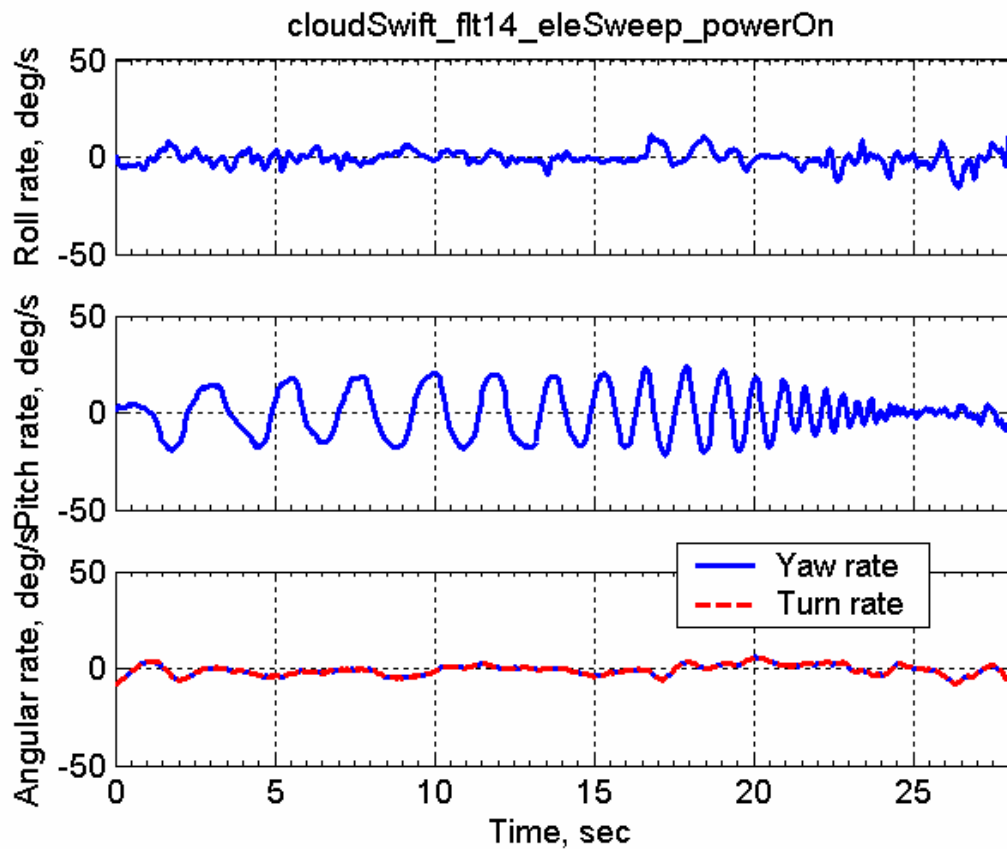
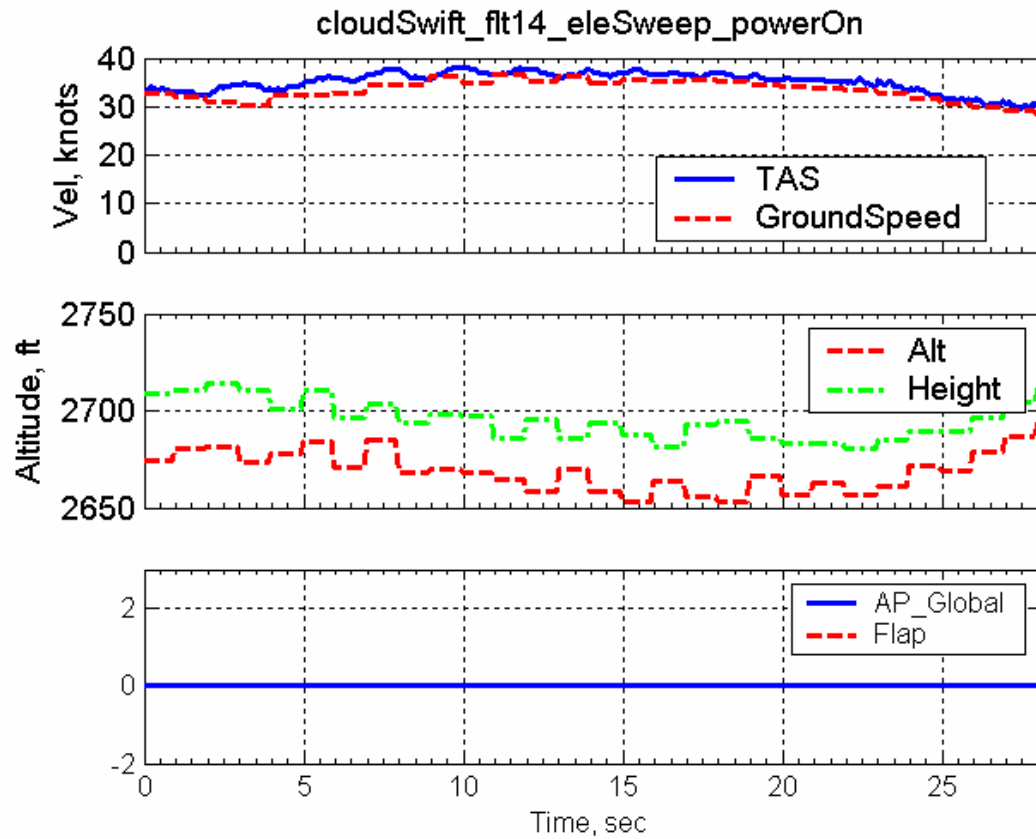


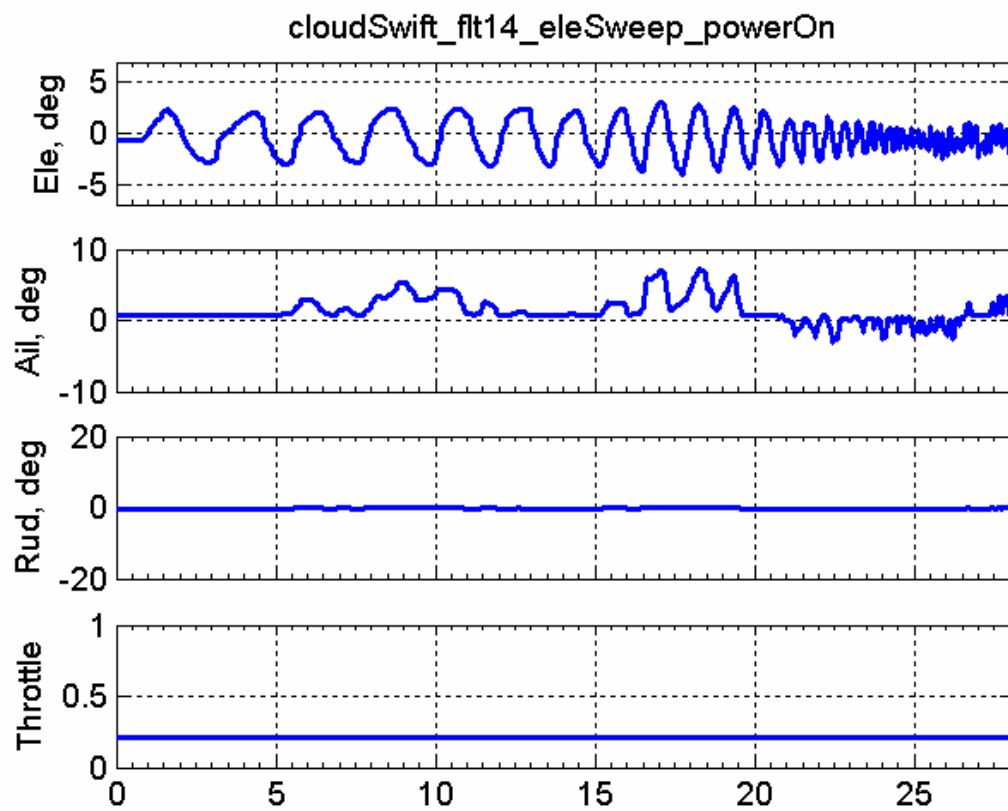
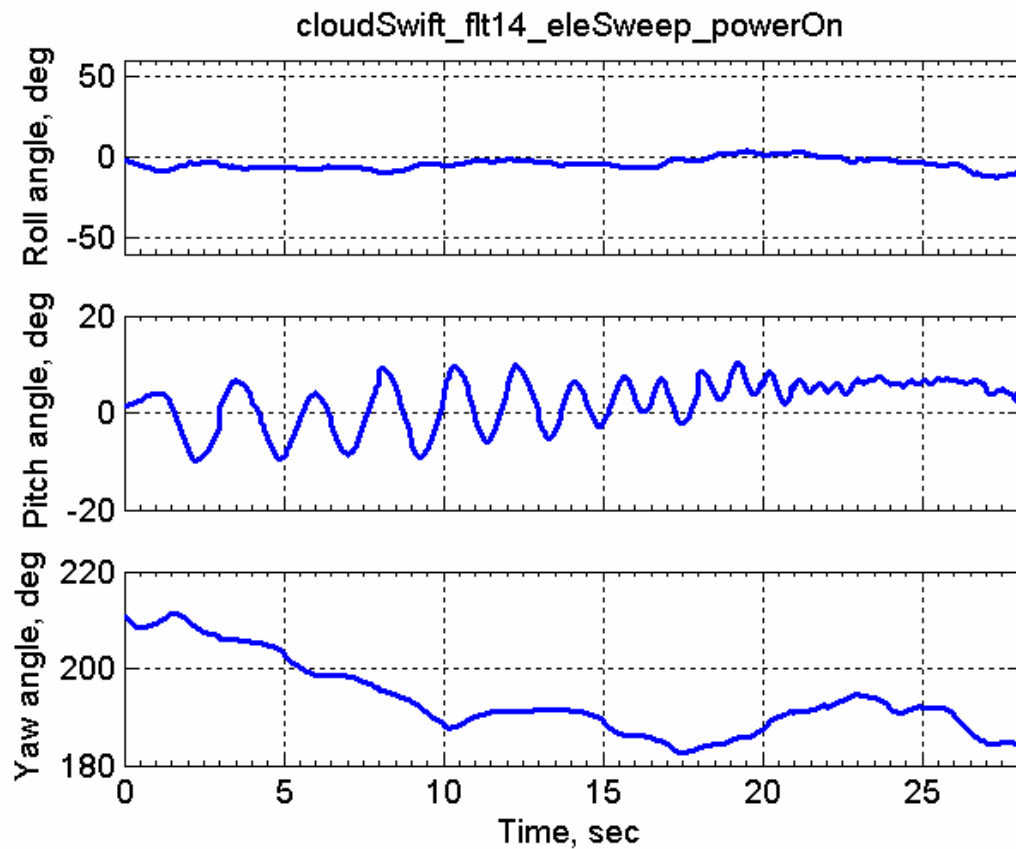




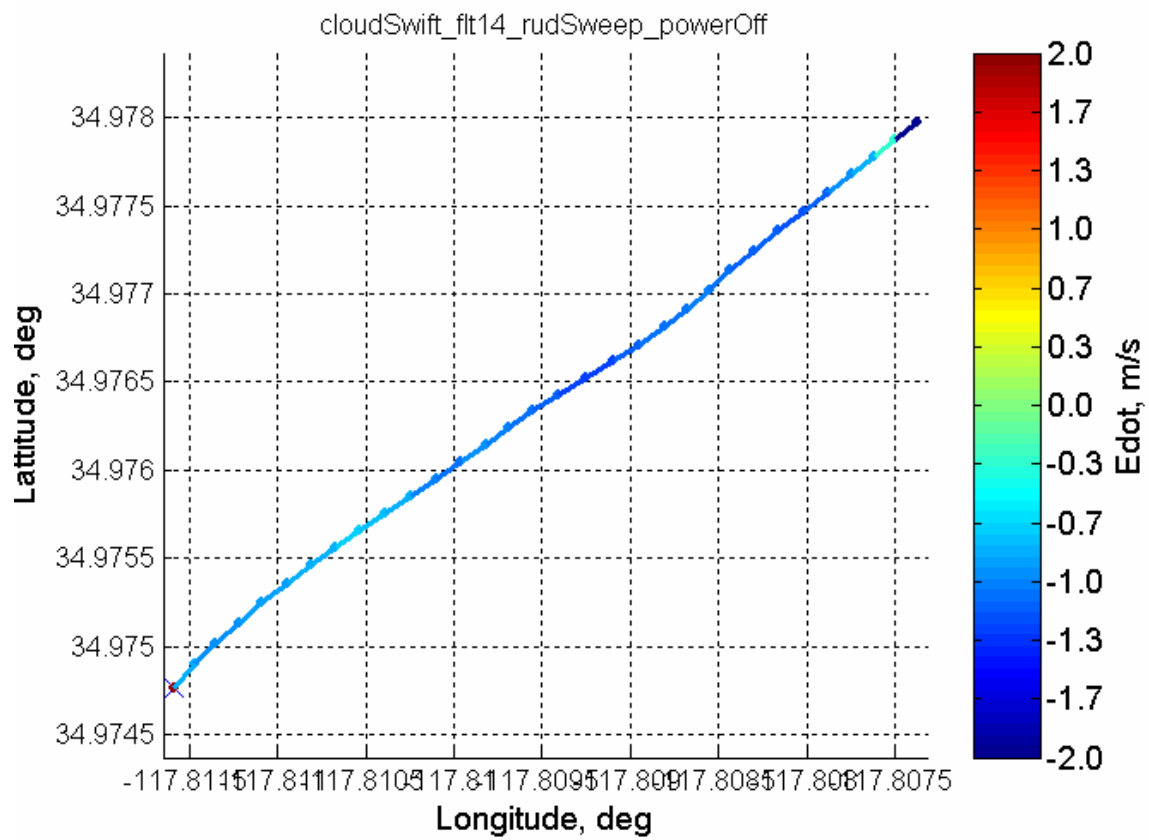
Flight 14, Elevator Sweep, Power On

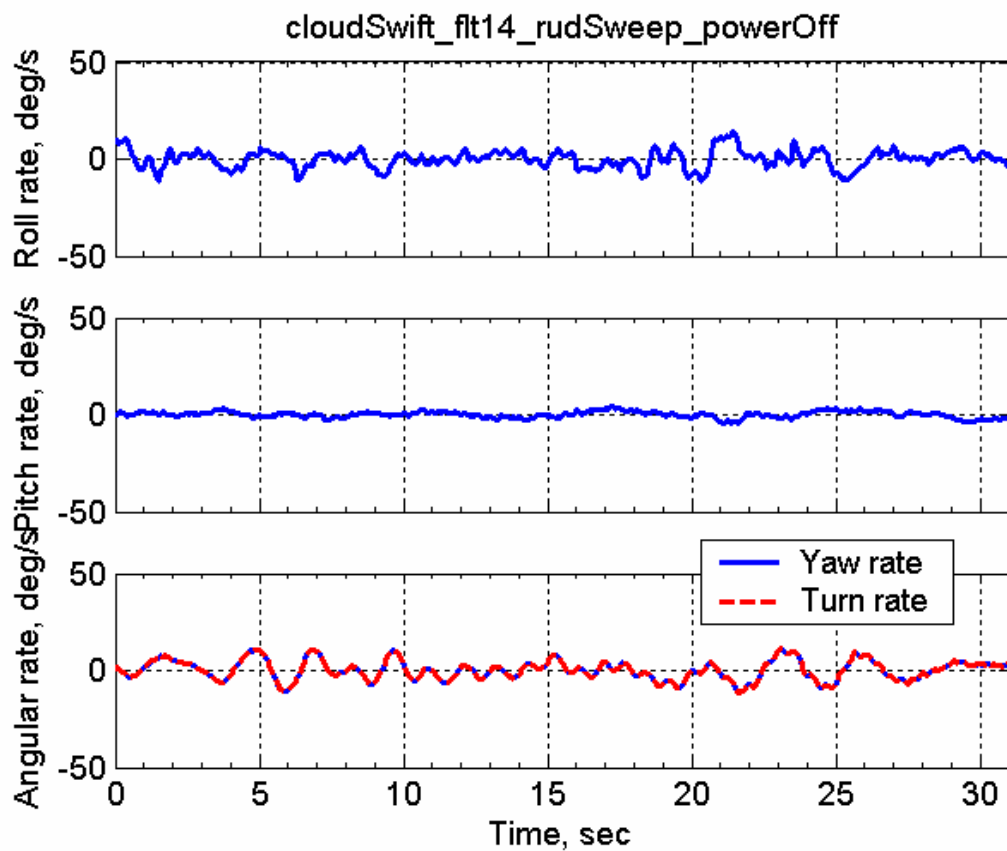
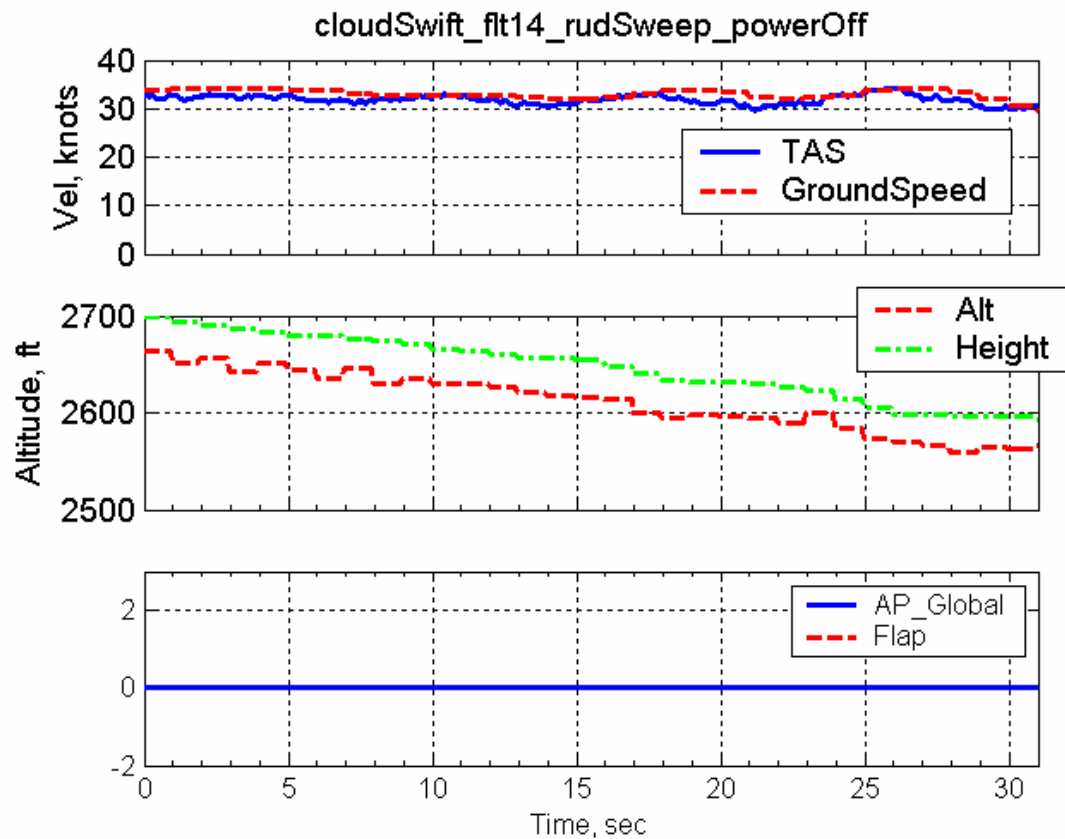


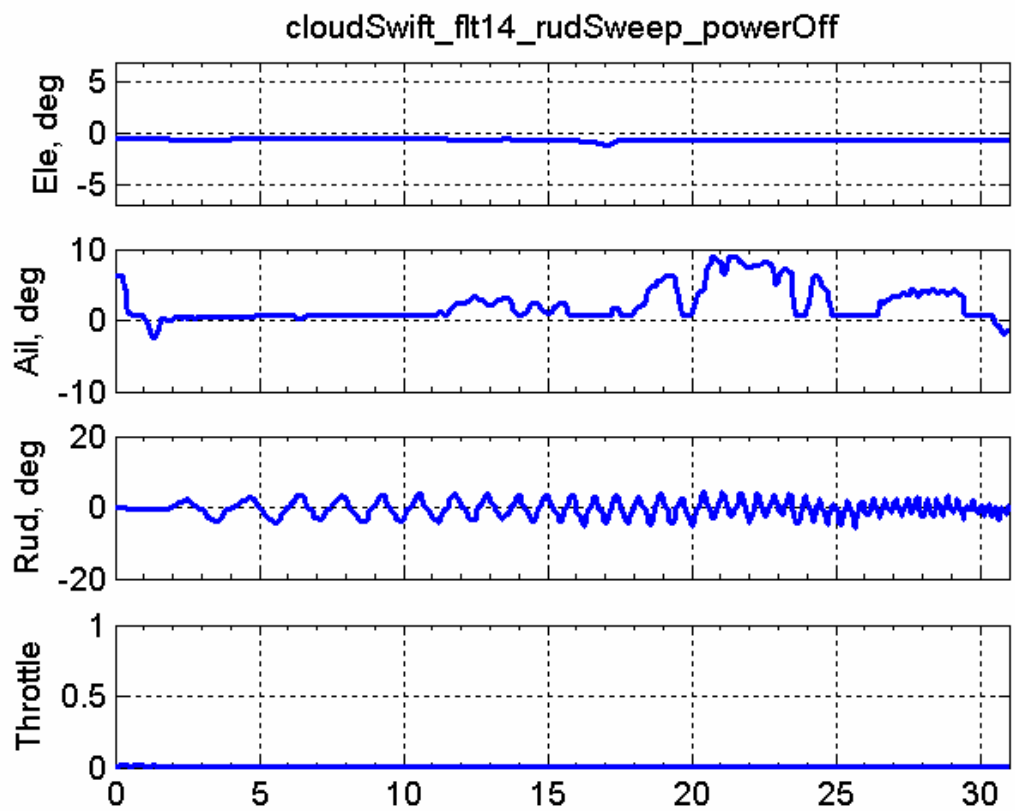
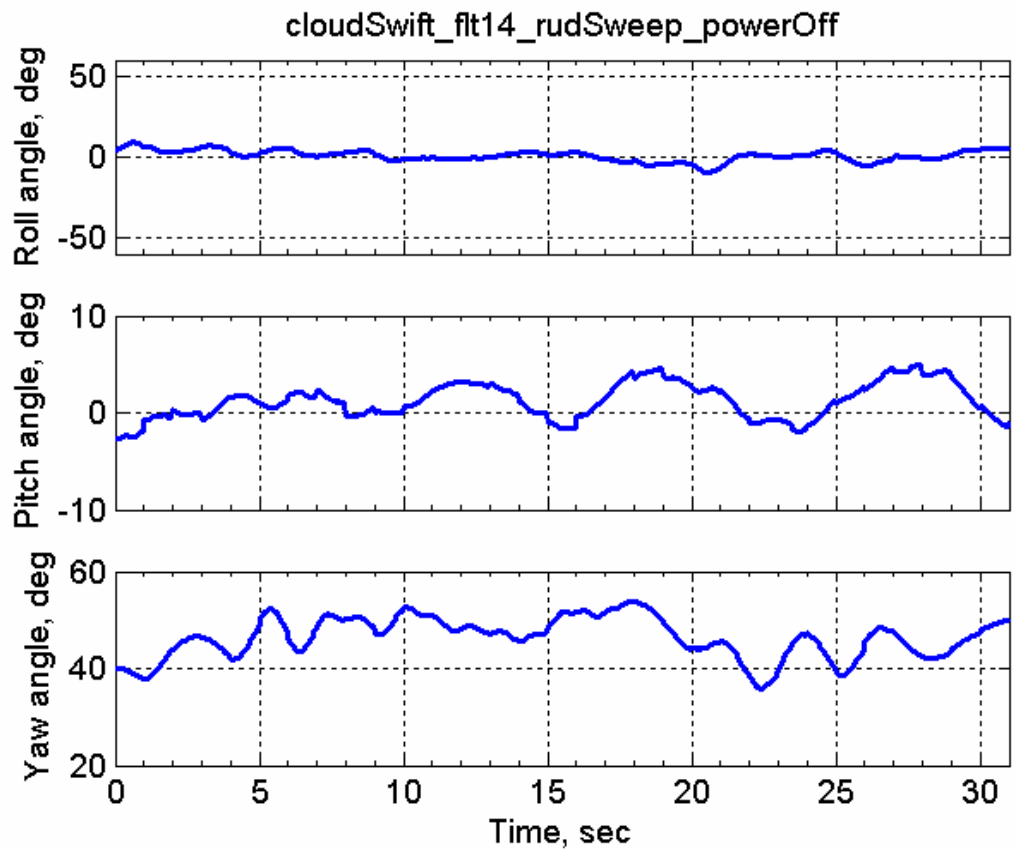




Flight 12, Rudder Sweep, Power Off

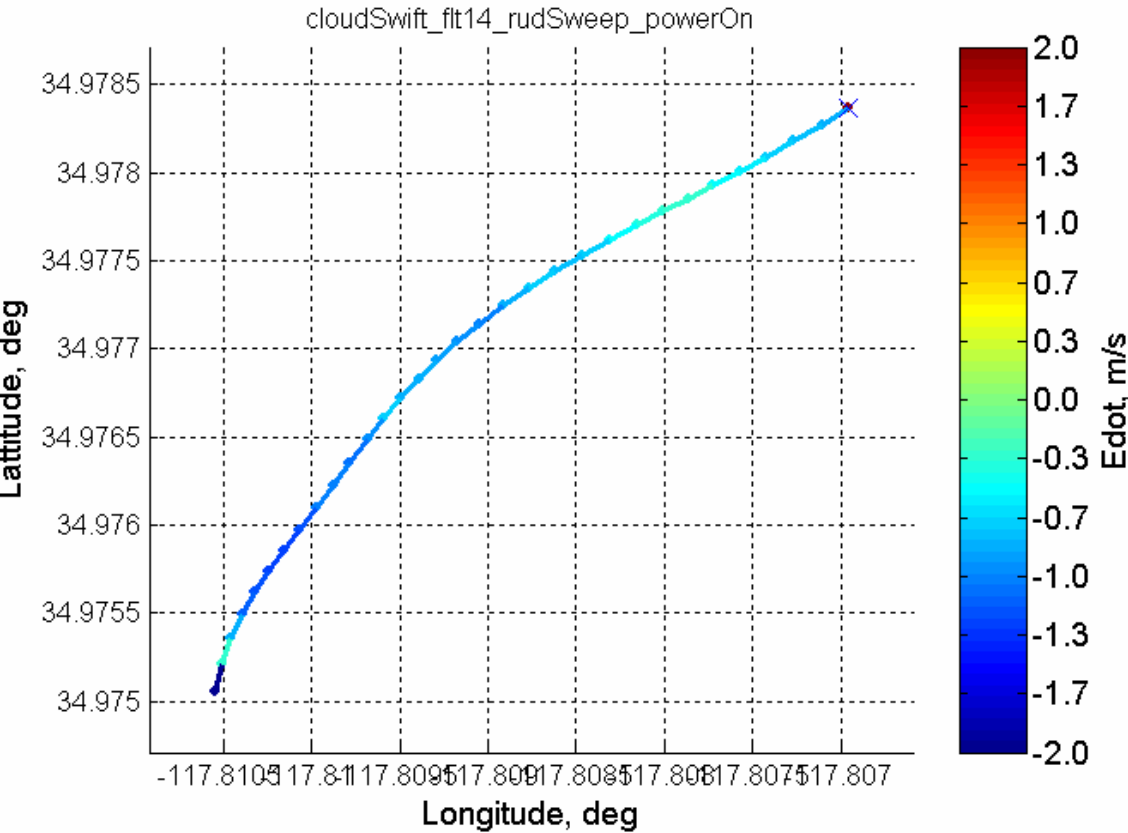


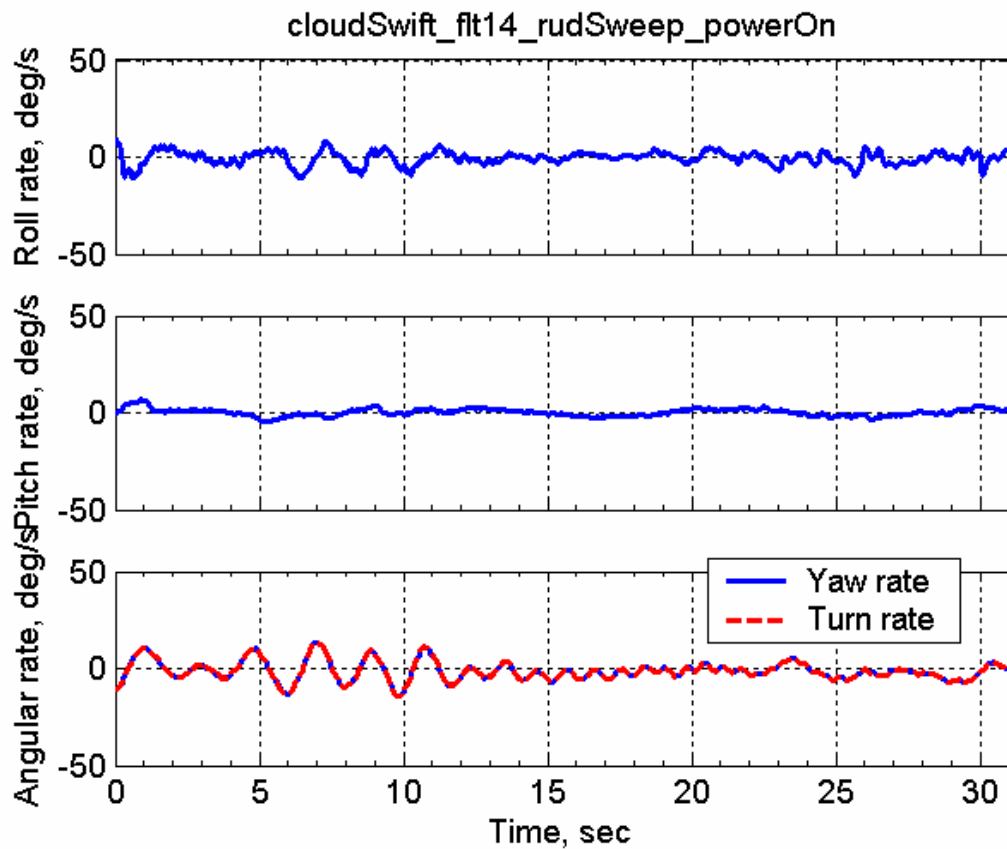
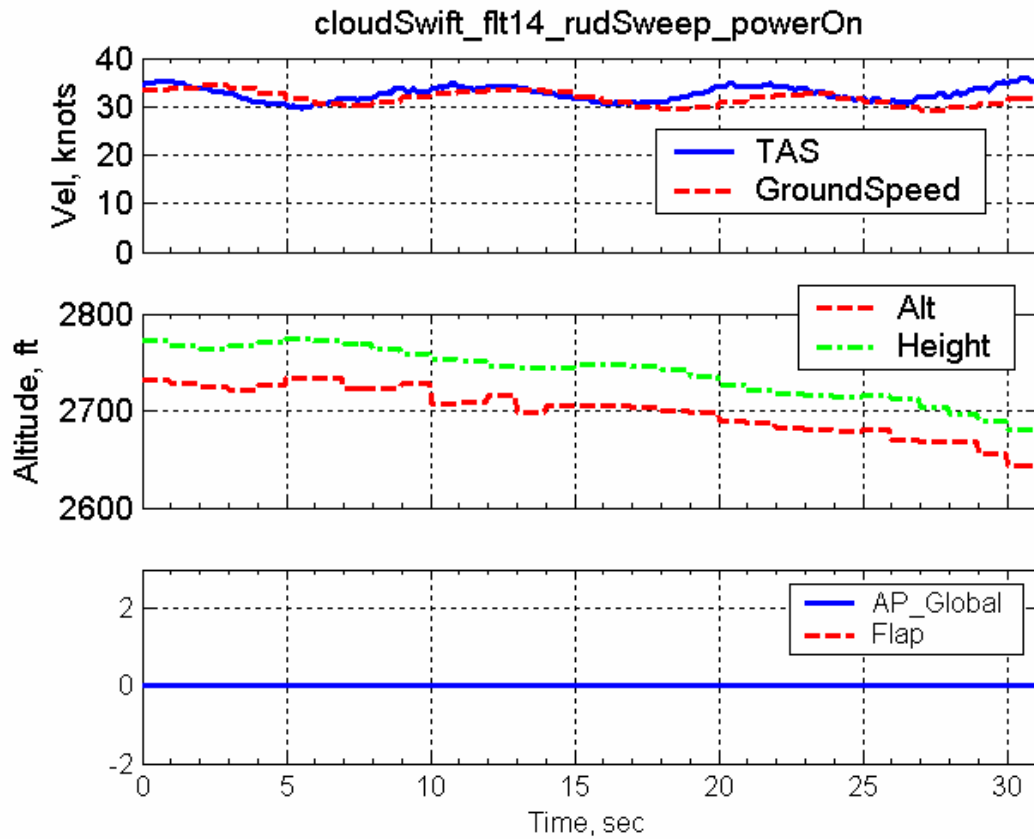


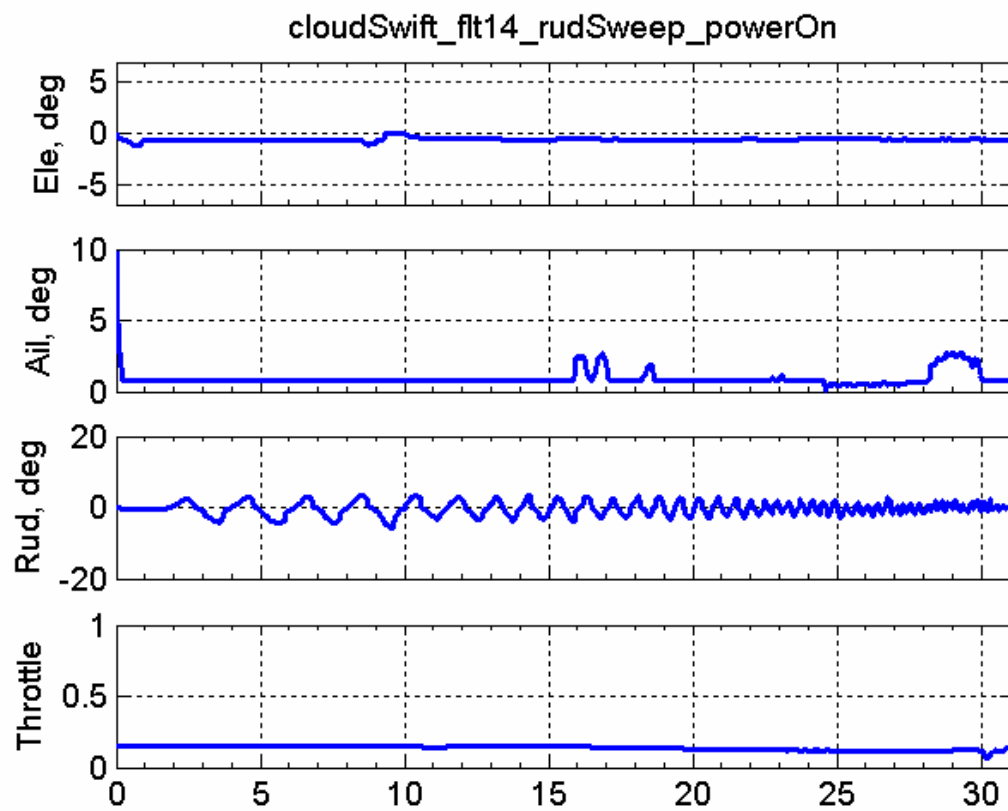
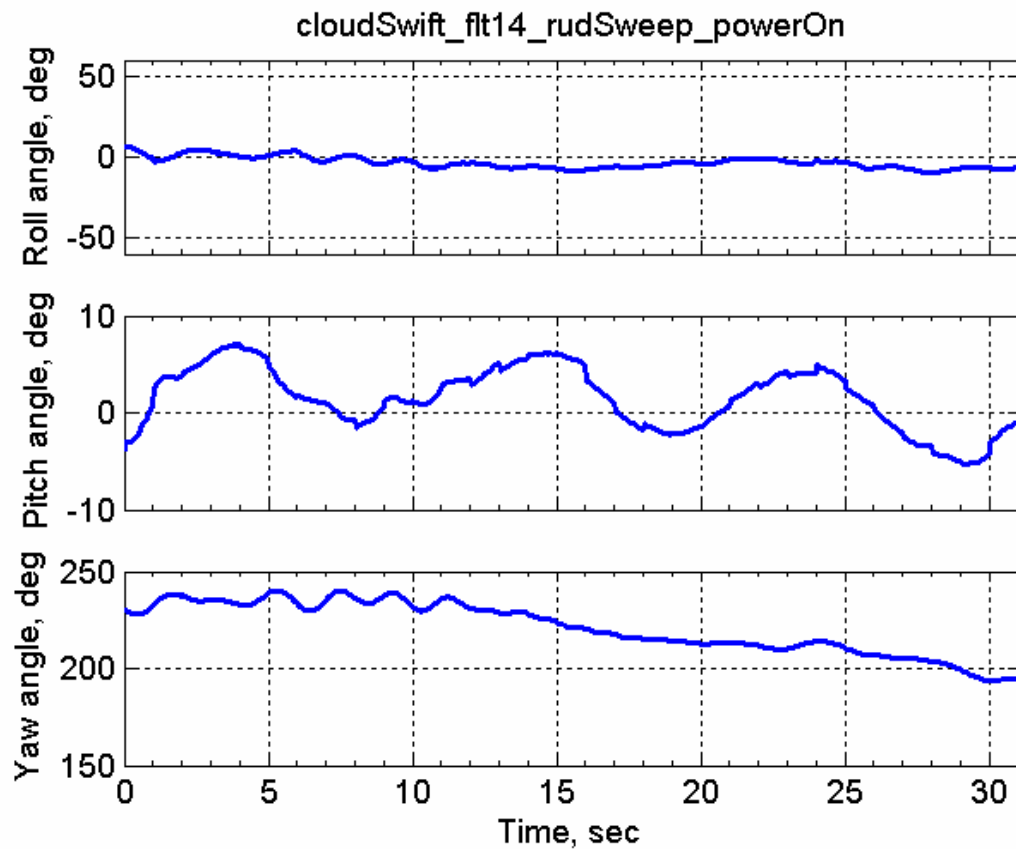


Flight 12, Rudder Sweep, Power On

Large pitch phugoid motion present

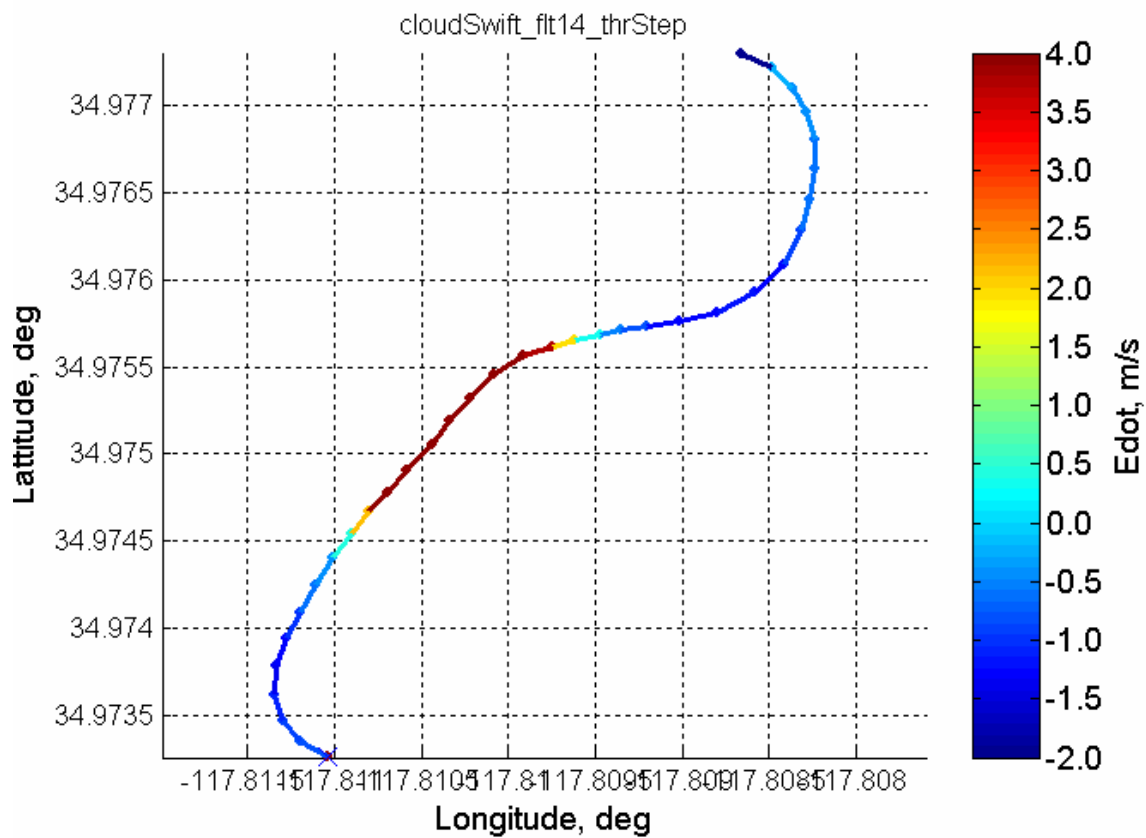


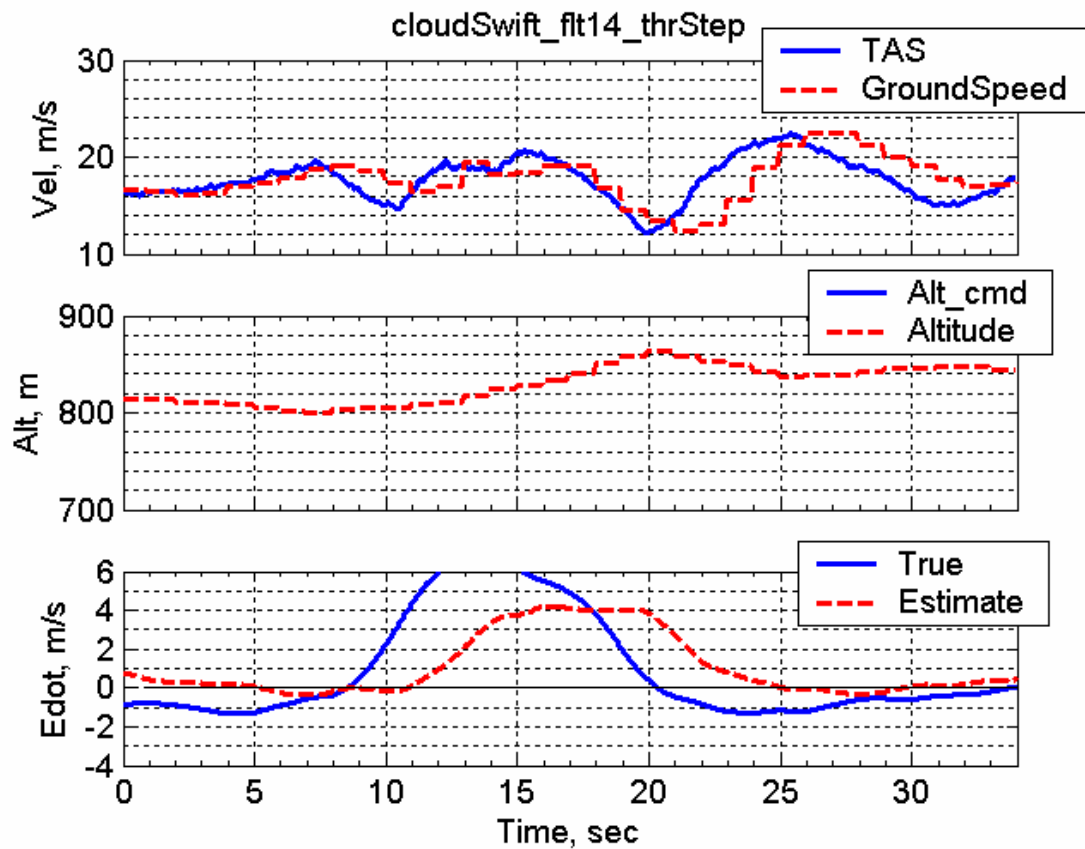
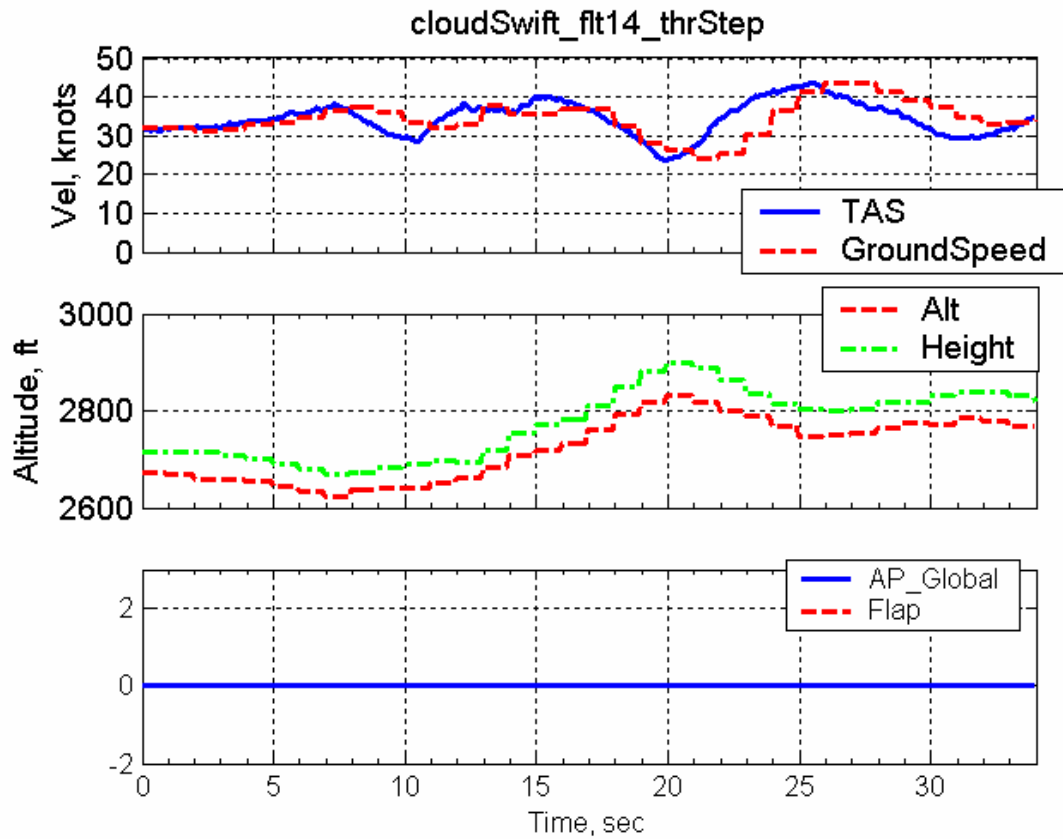


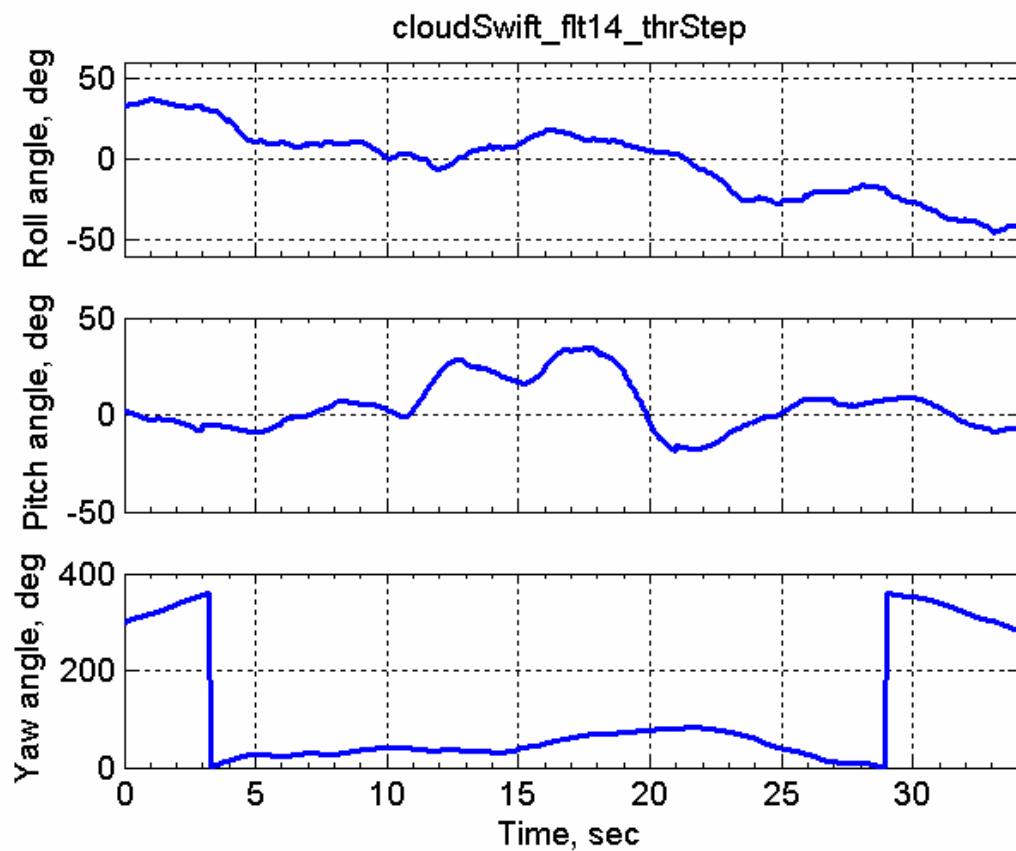
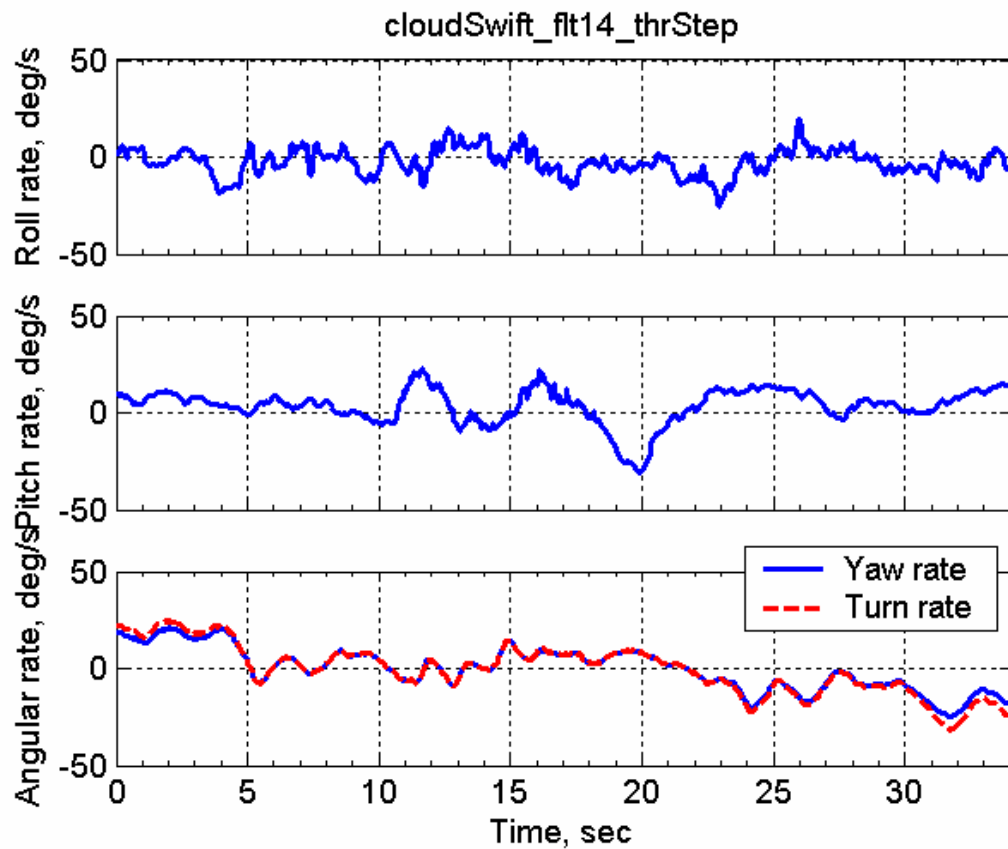


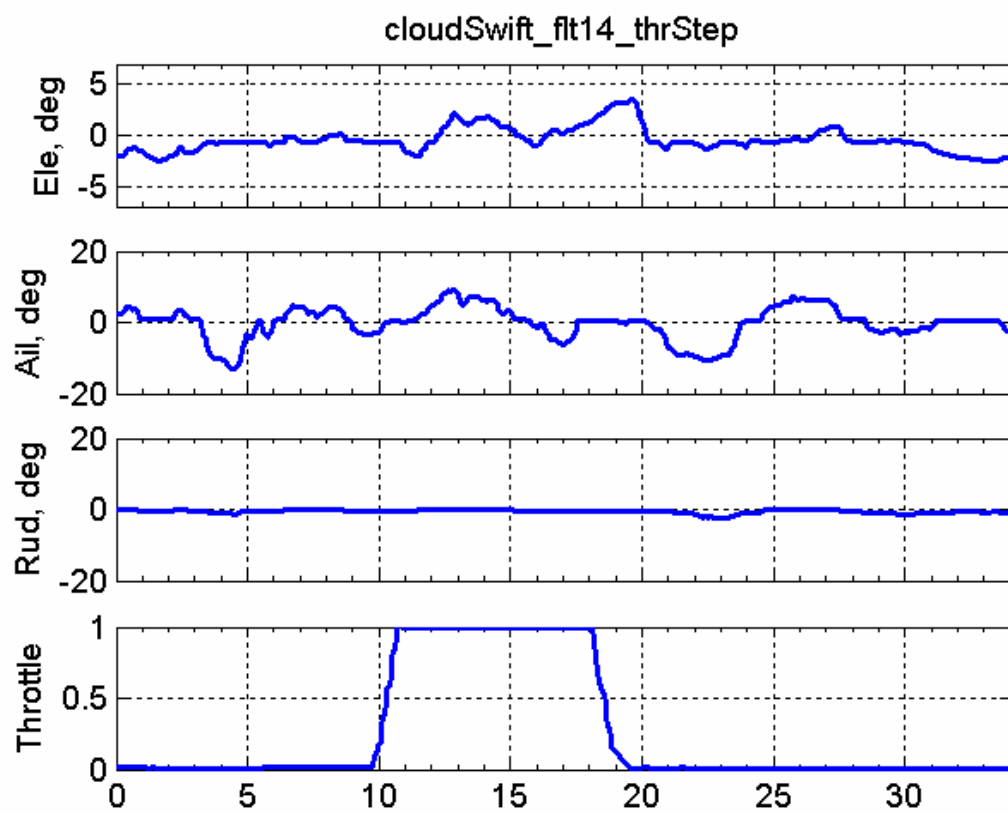
Flight 14, Throttle Step

Estimated Edot should remain around zero because engine effects are removed. The engine model found in the edot estimation blocks needs to be tuned with more data. The throttle vs. edot curve is likely nonlinear.

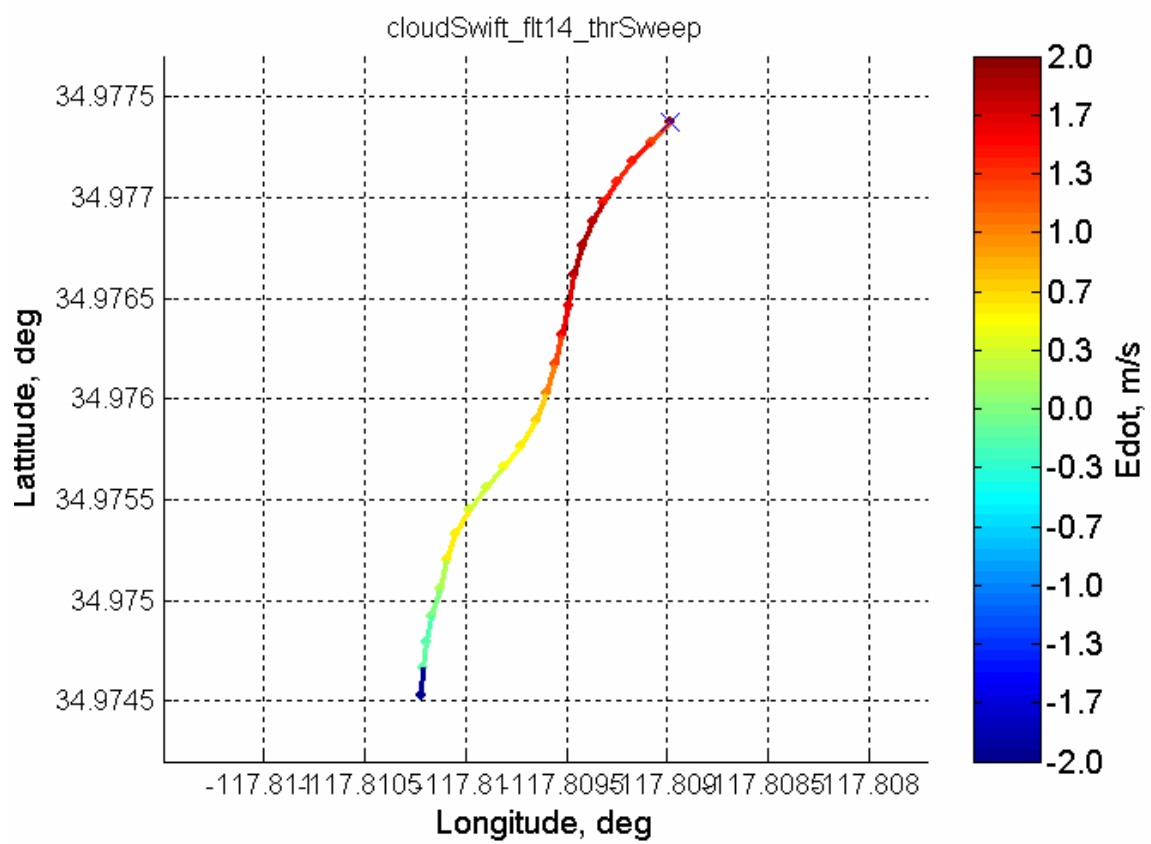


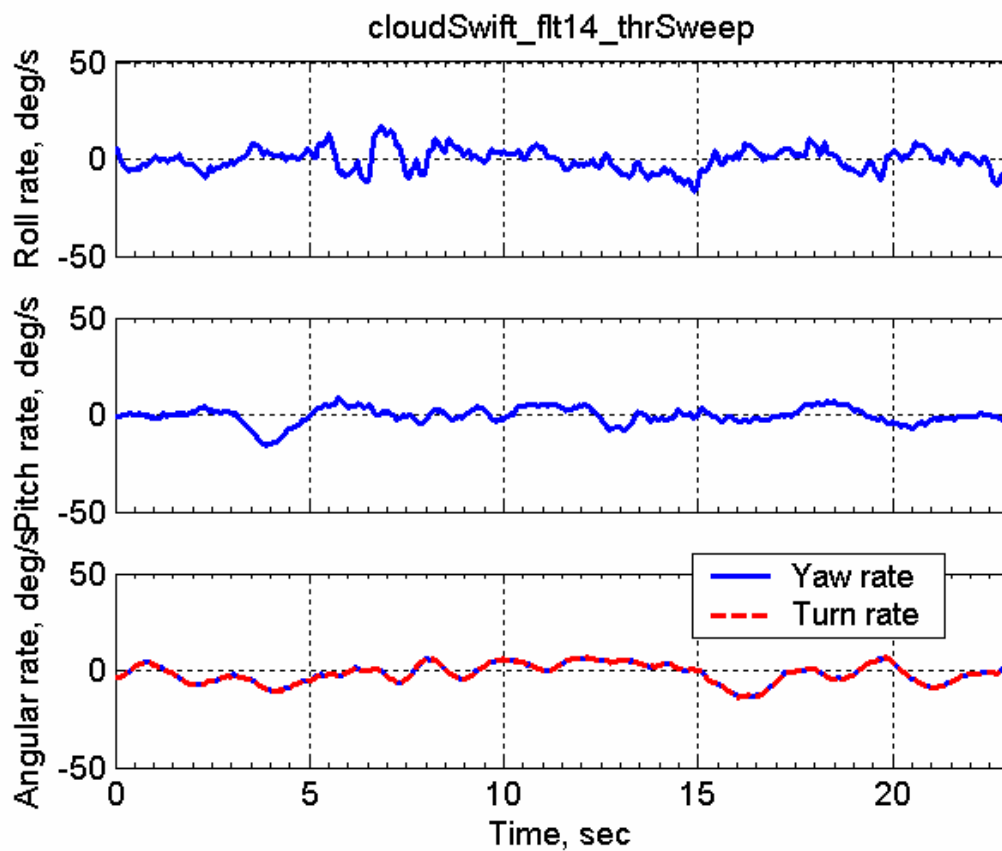
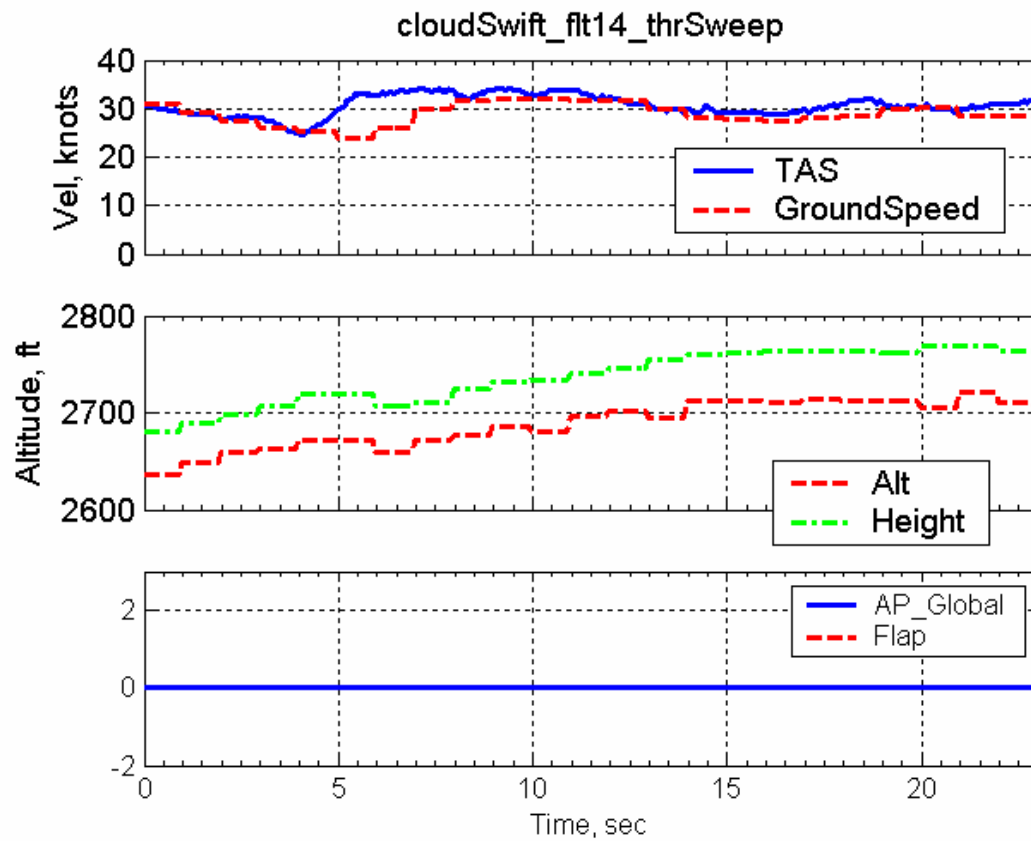


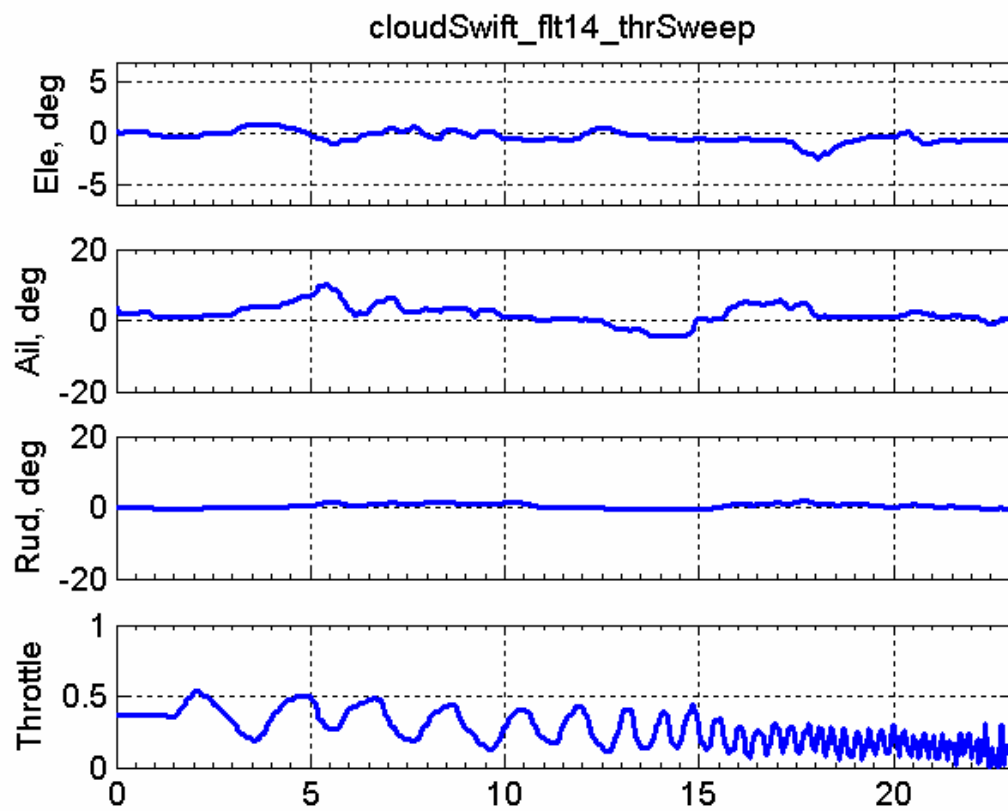
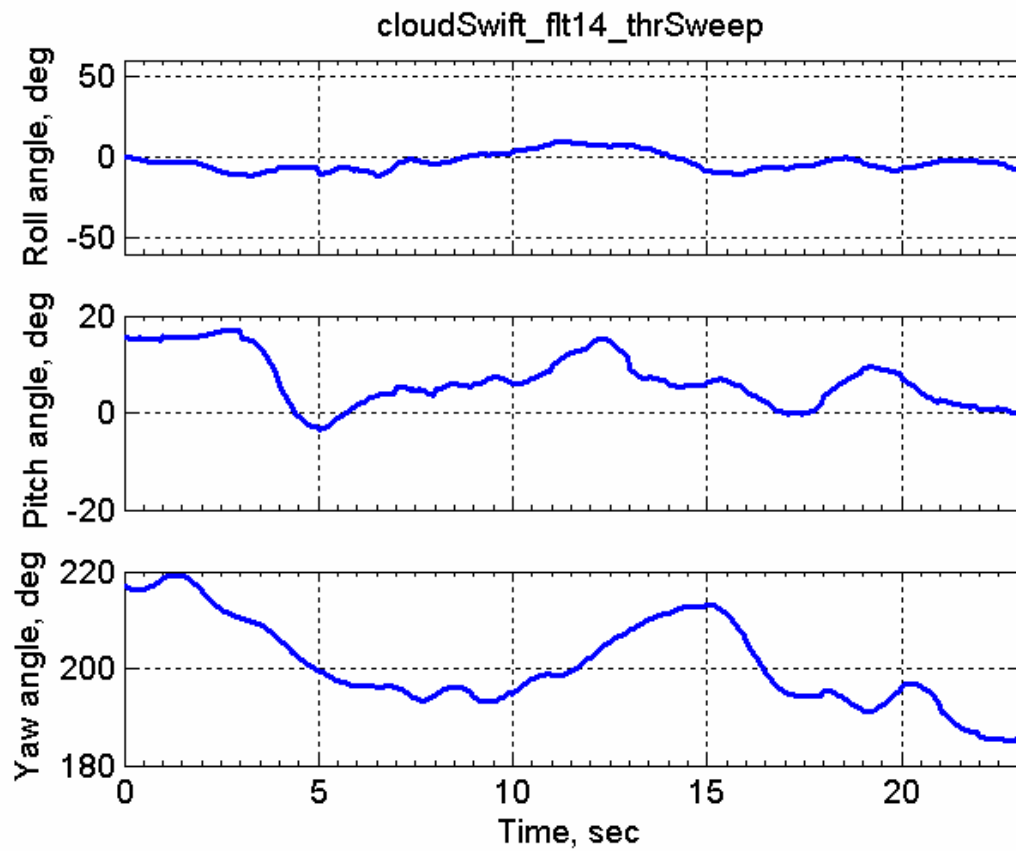




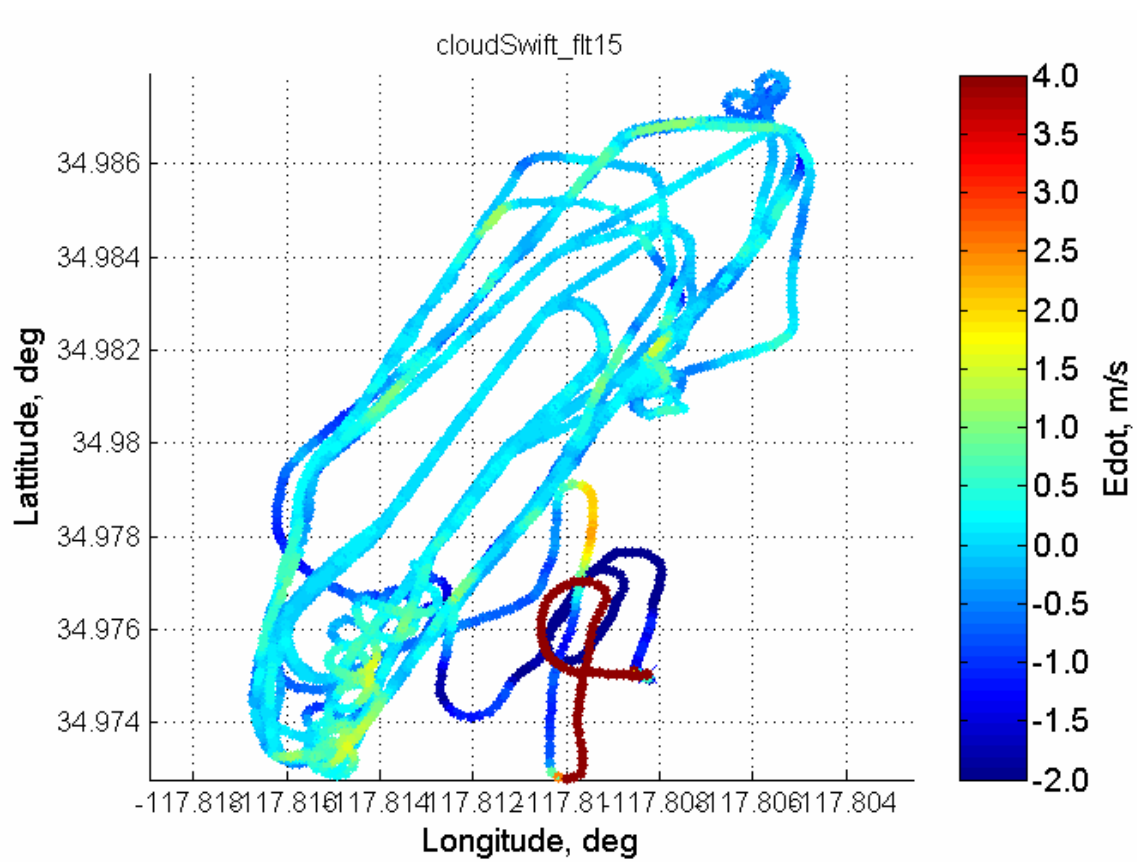
Flight 14, Throttle Sweep

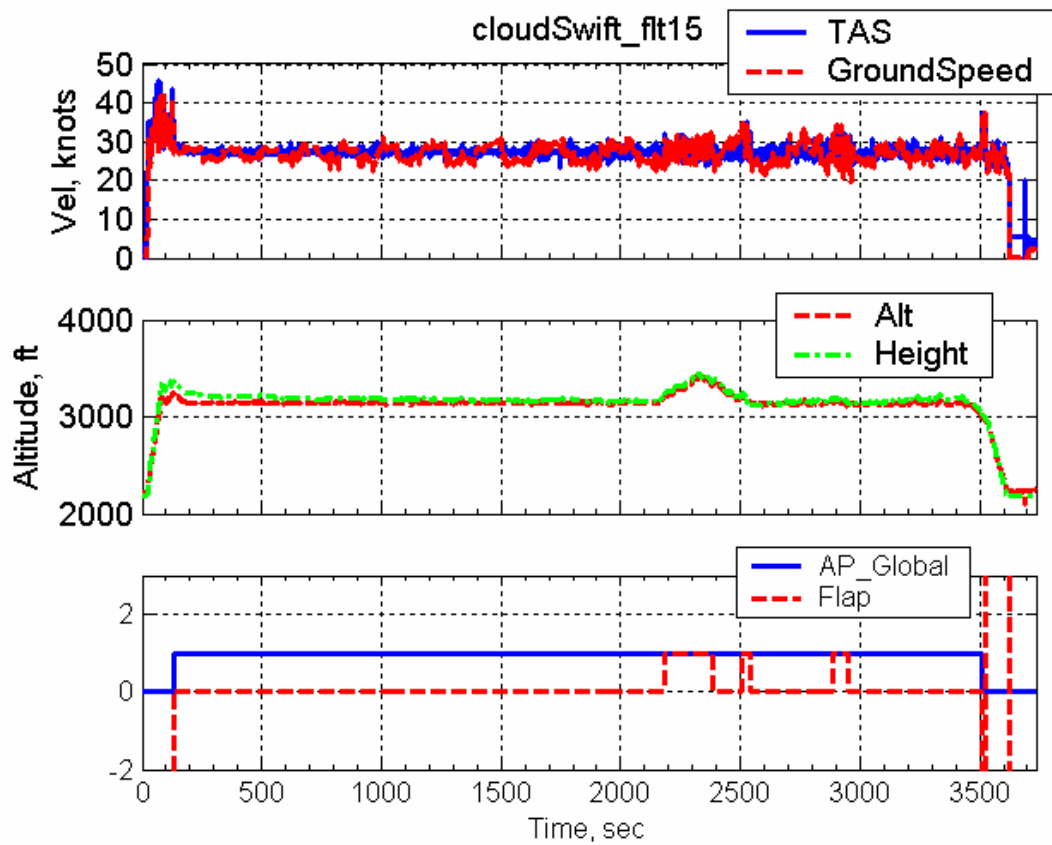
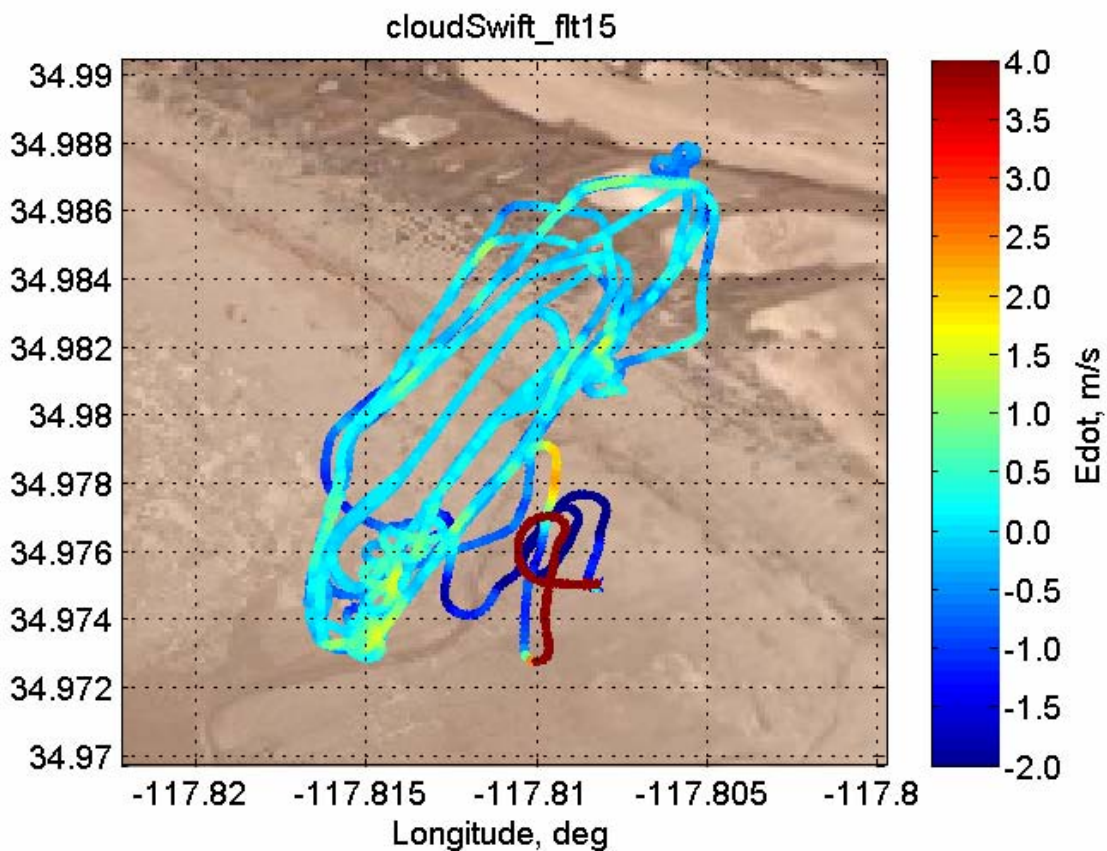


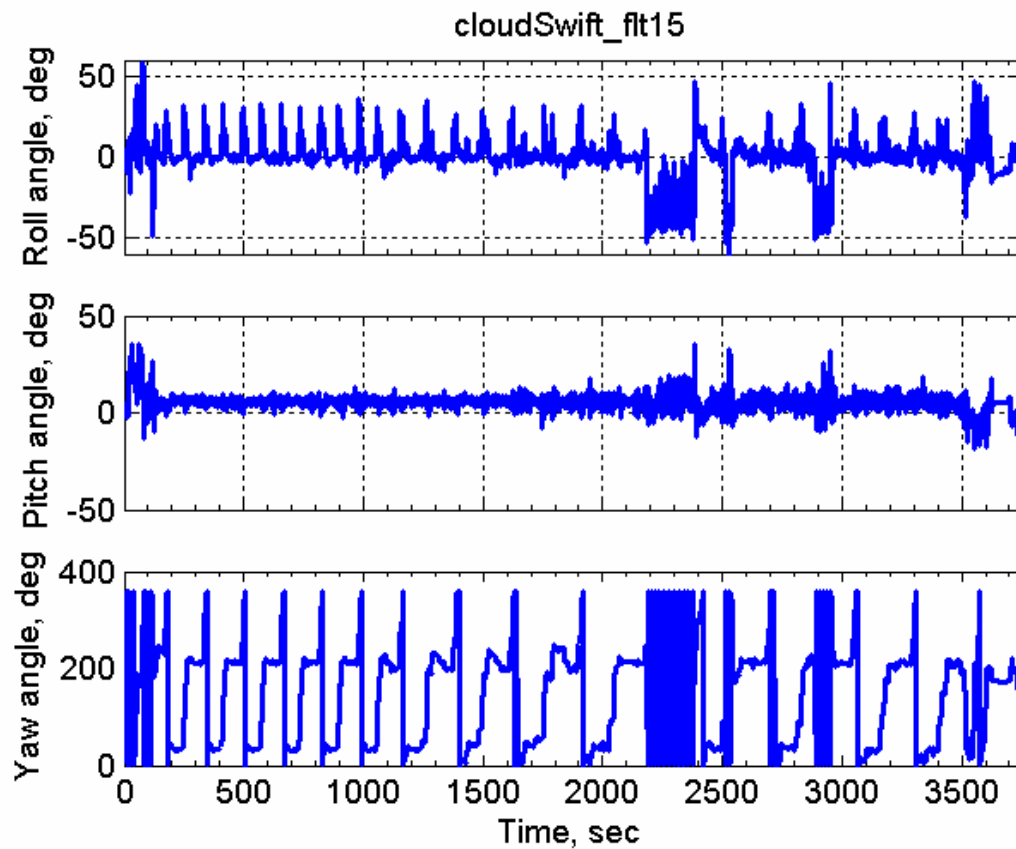
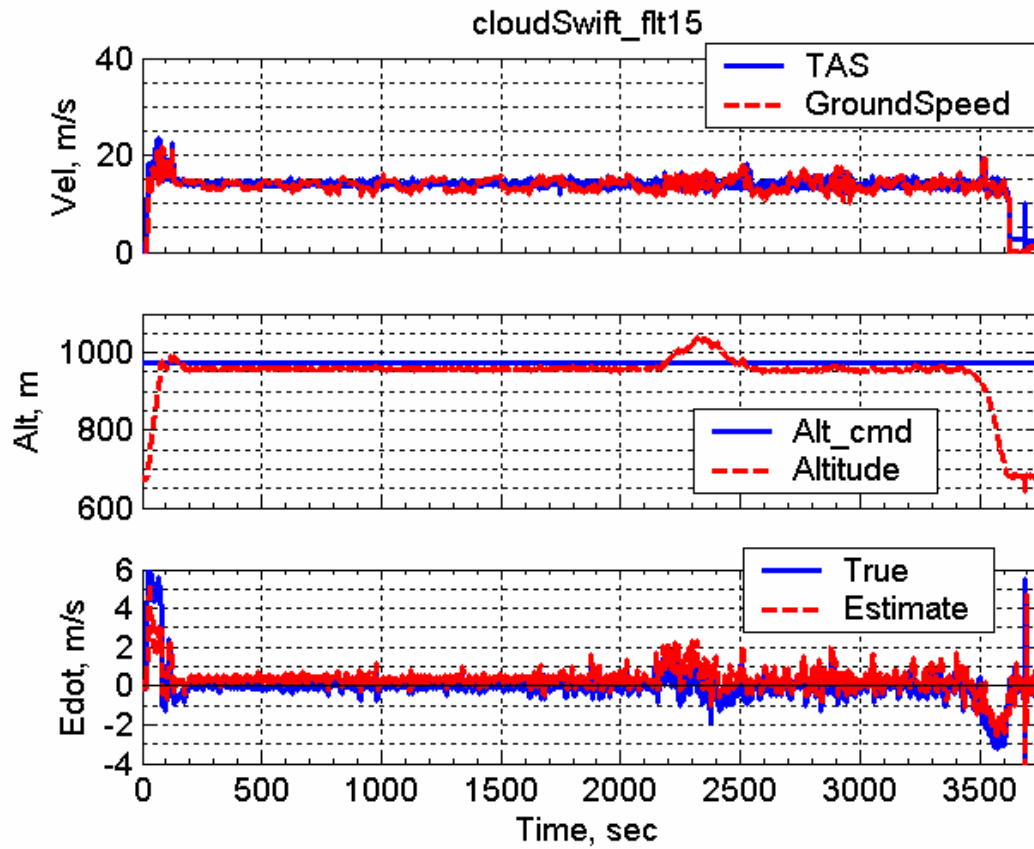




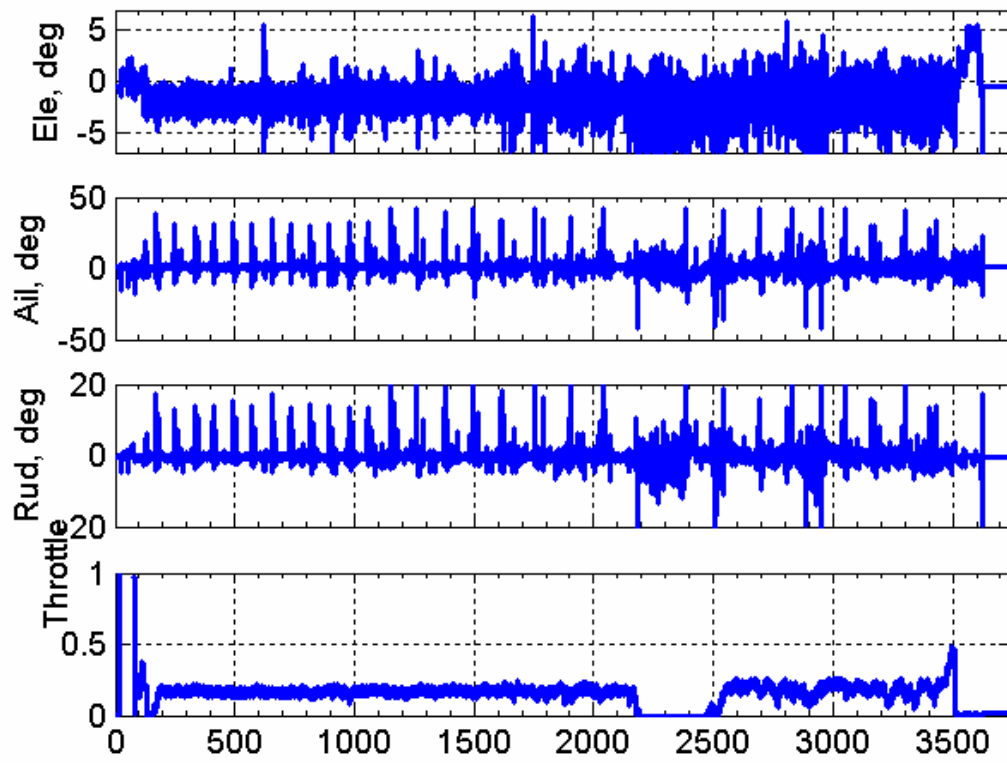
Flight 15



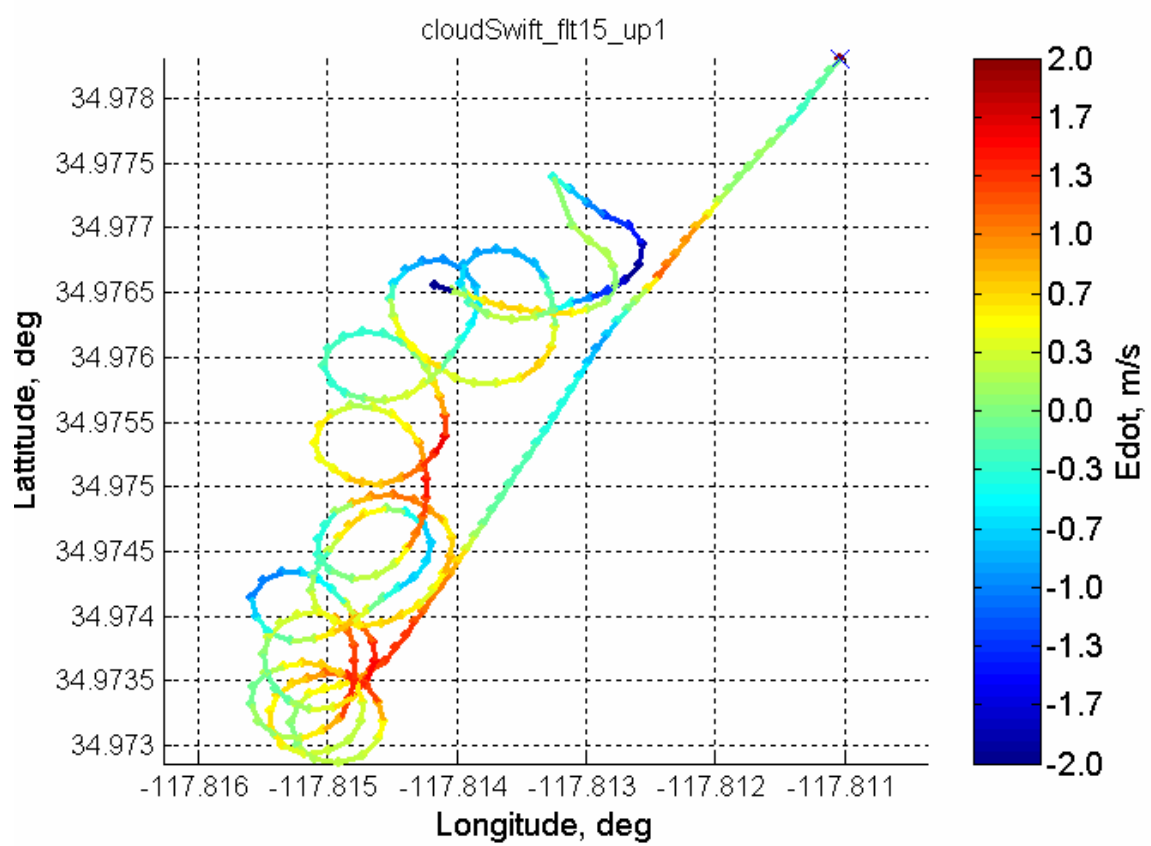


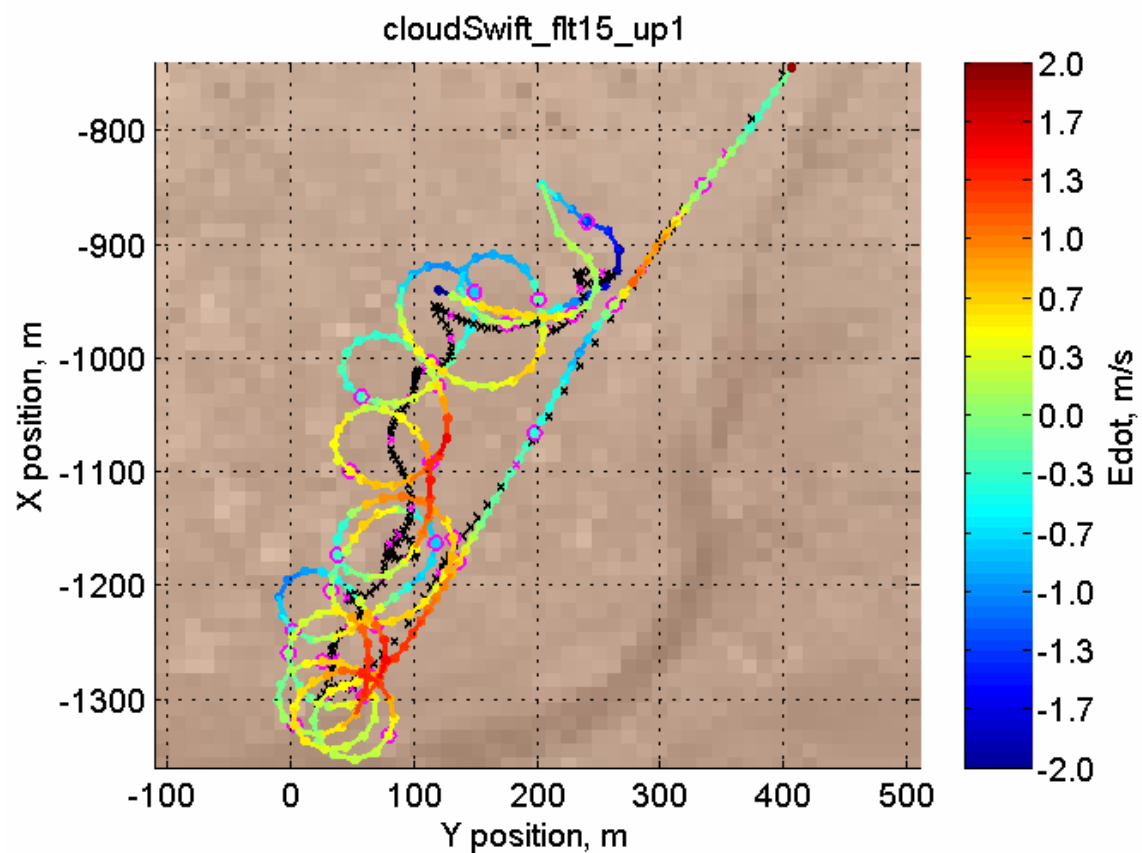
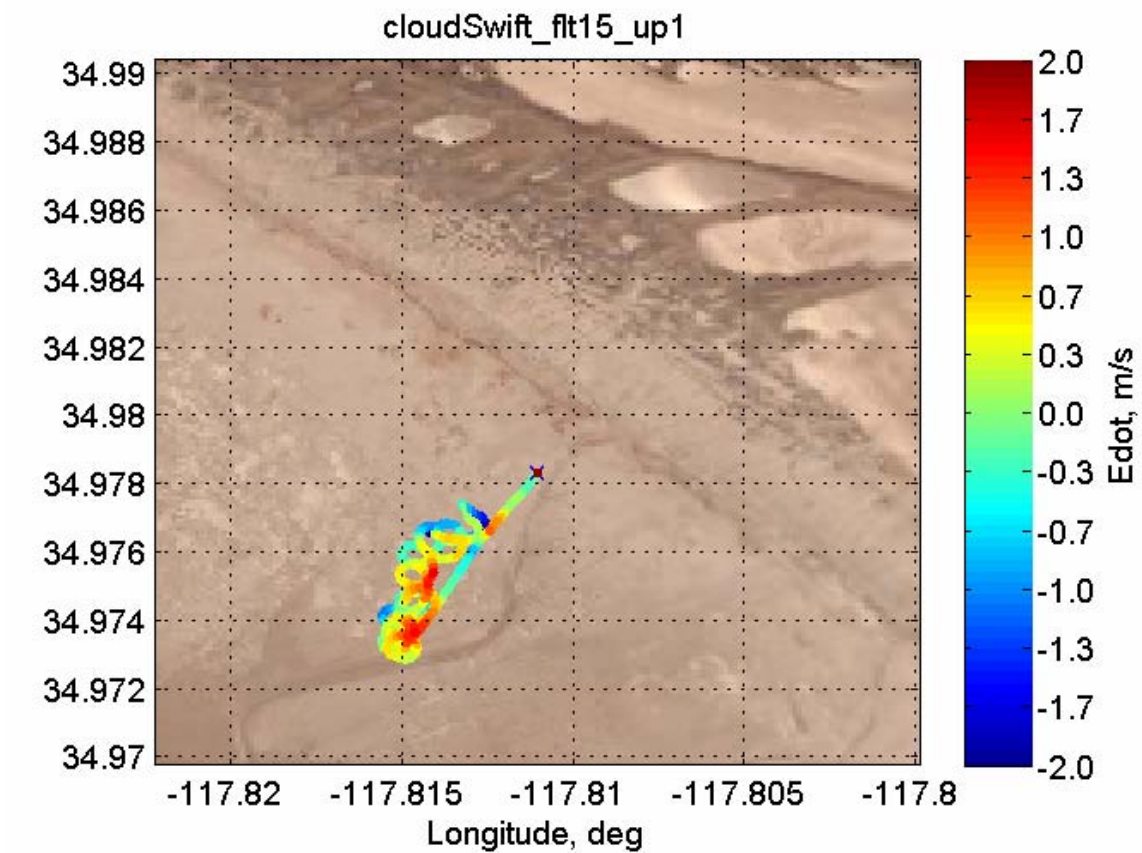


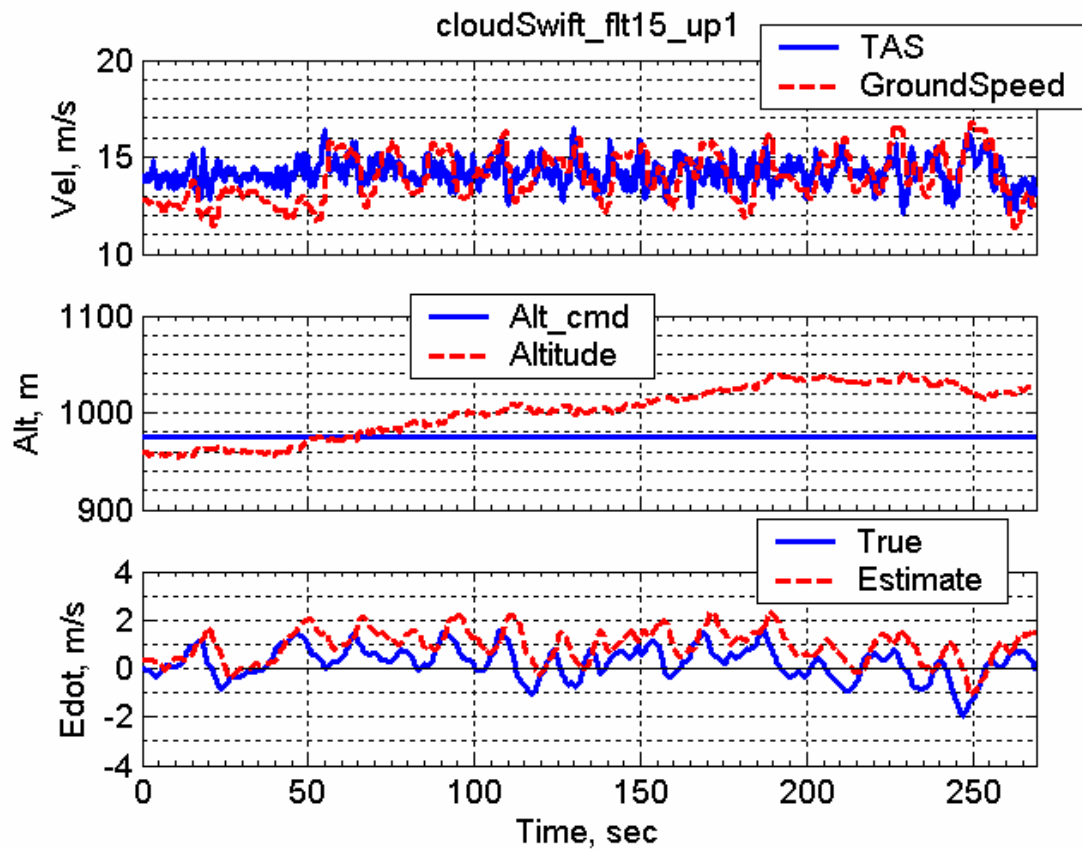
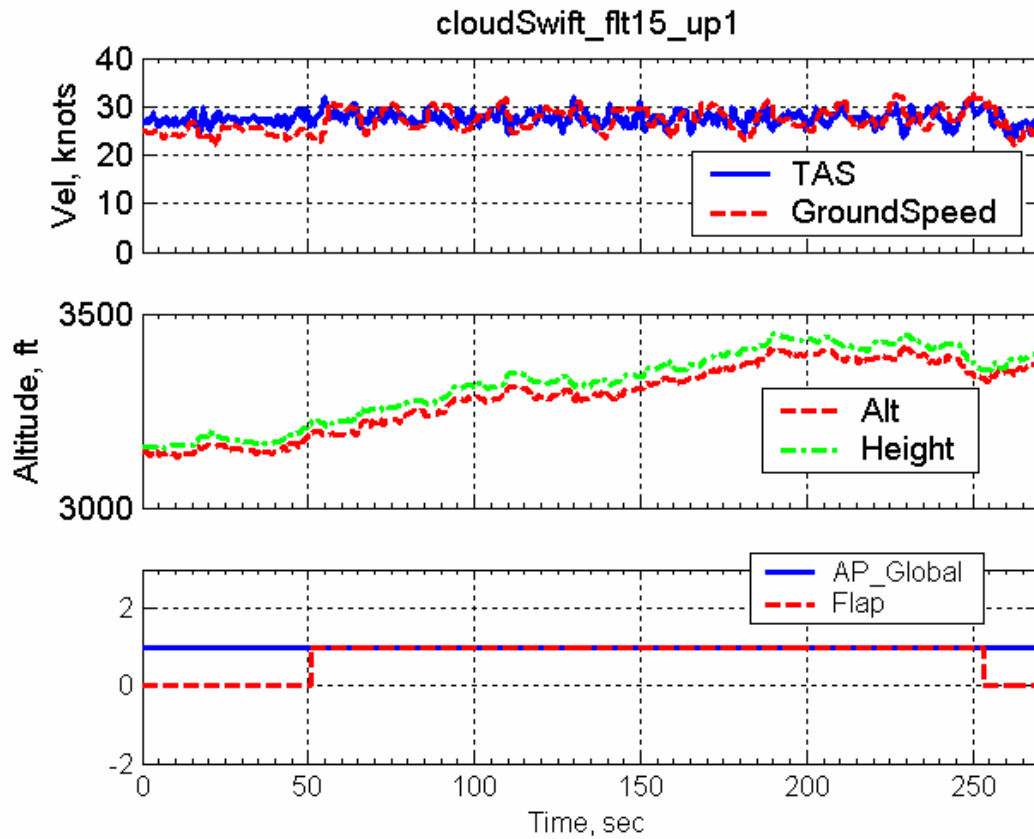
cloudSwift_ft15

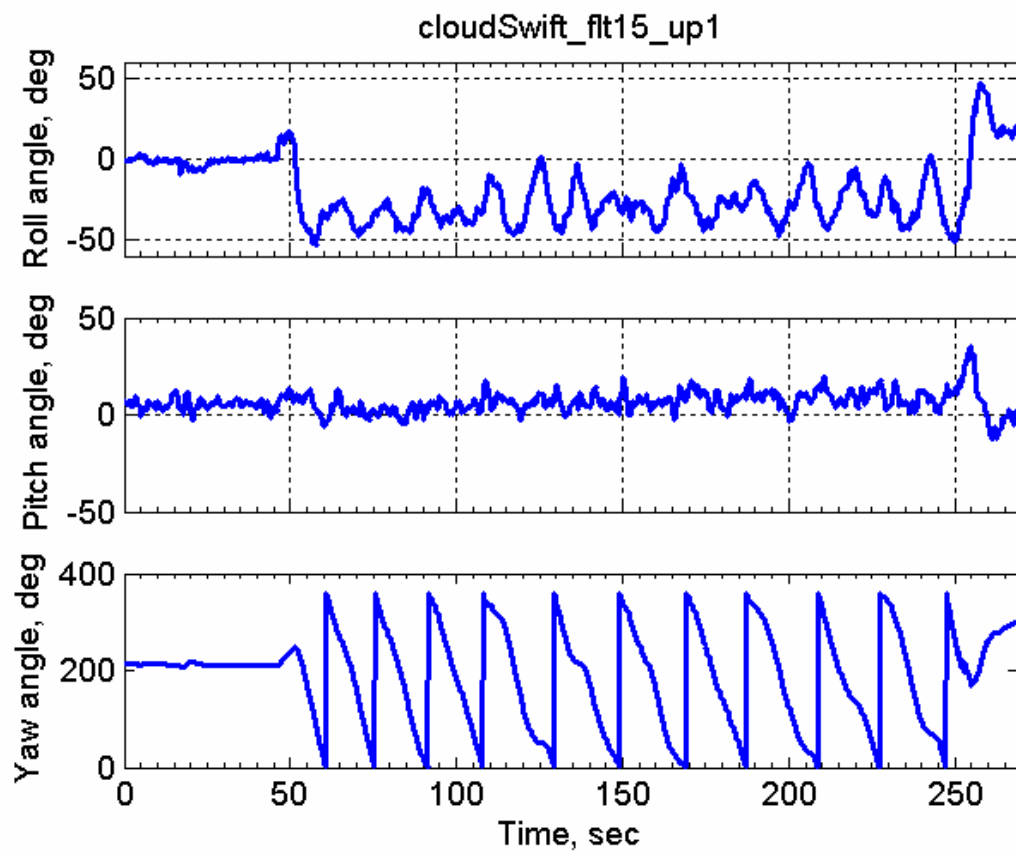
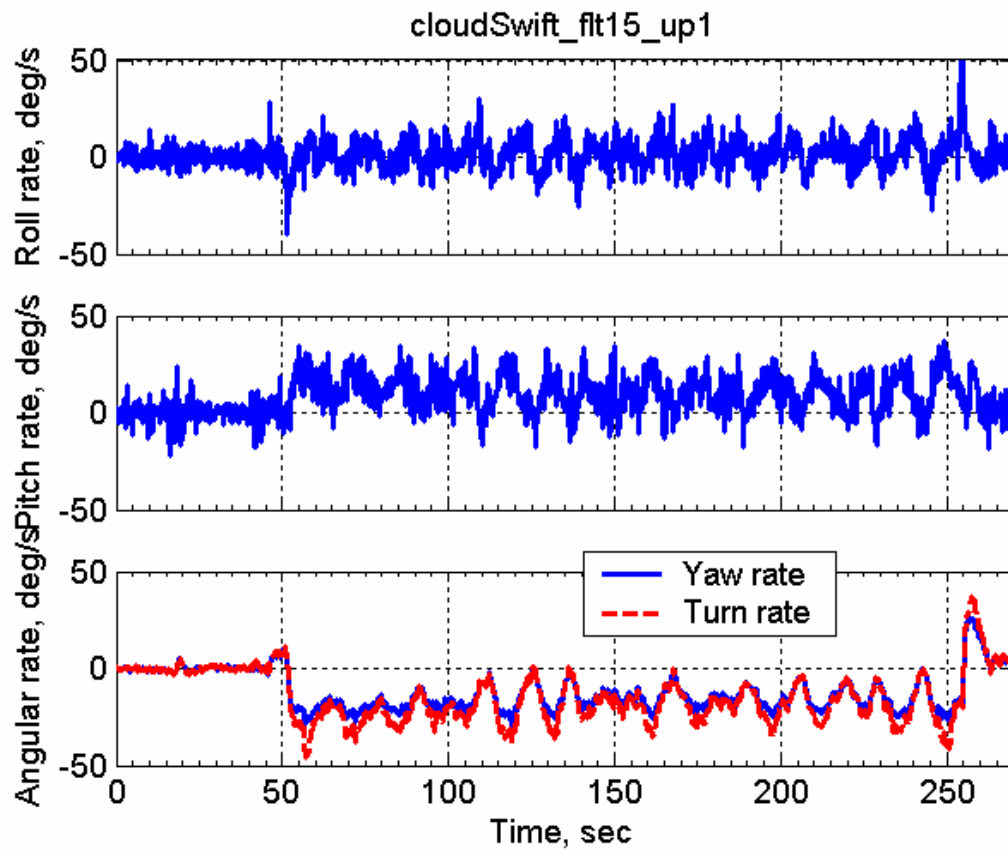


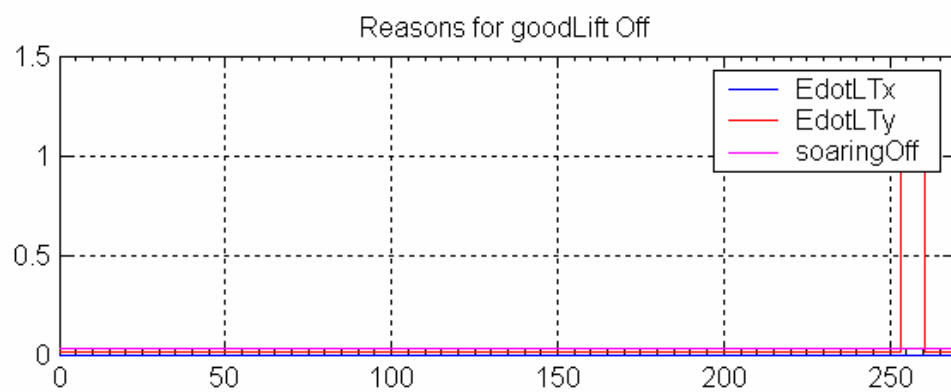
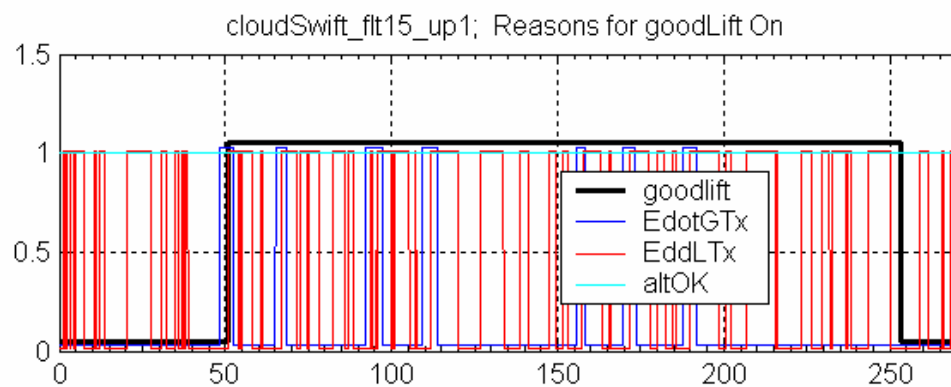
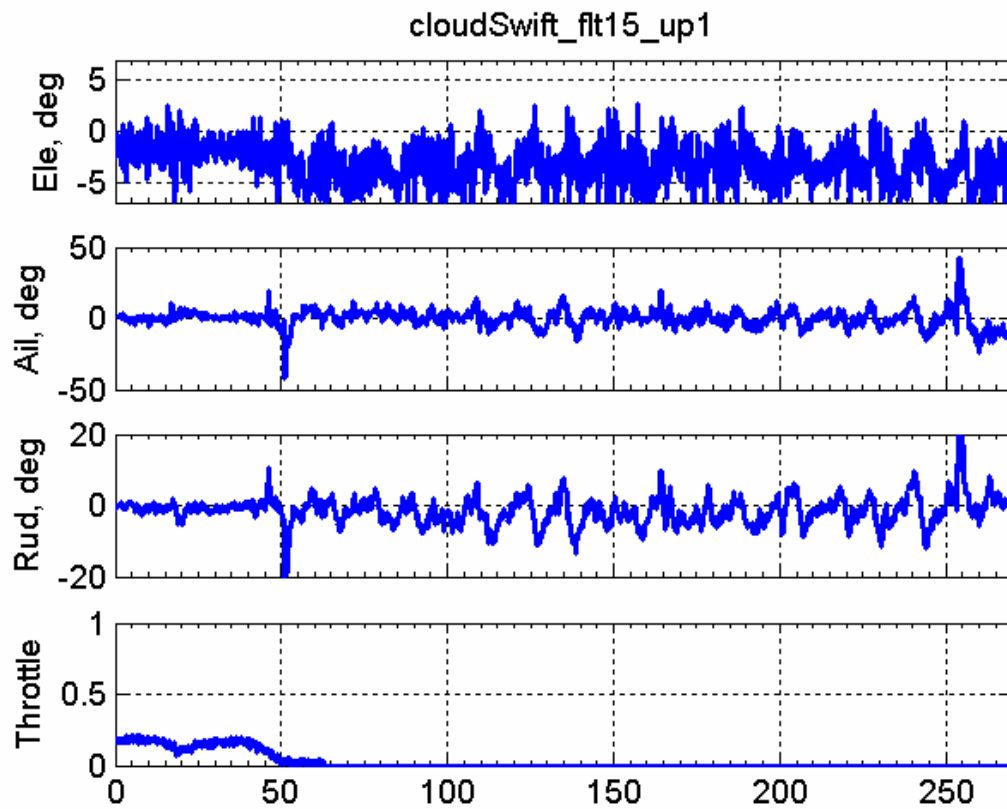
Flight 15, updraft 1

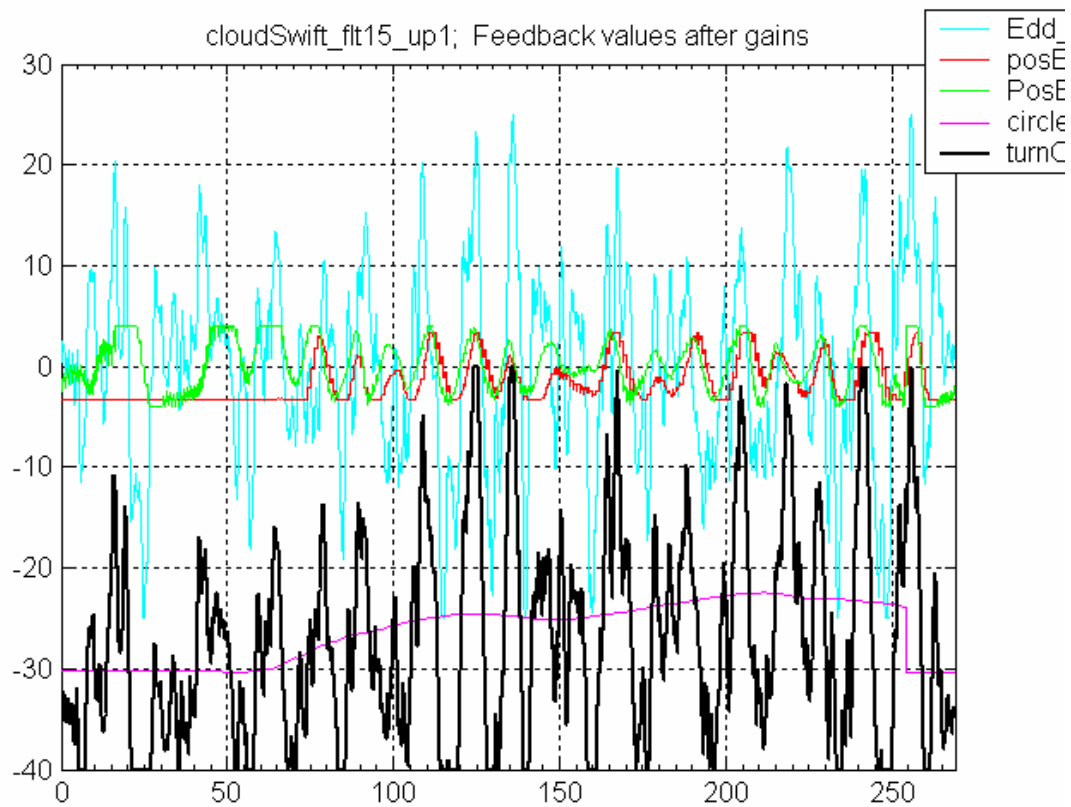
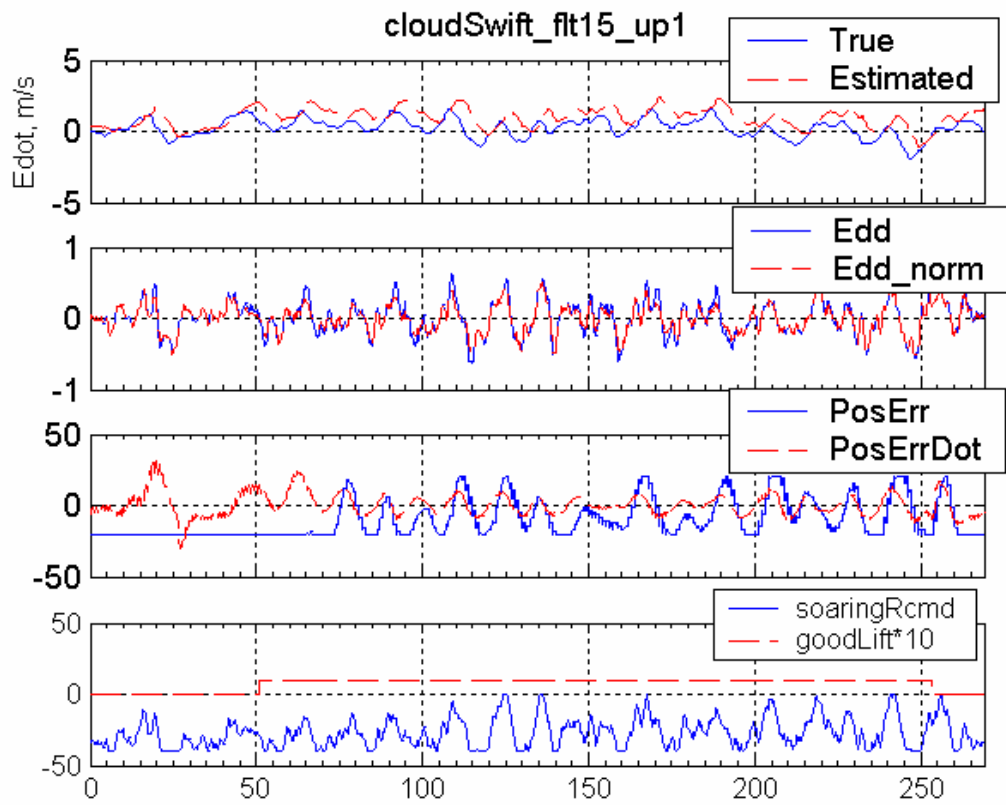




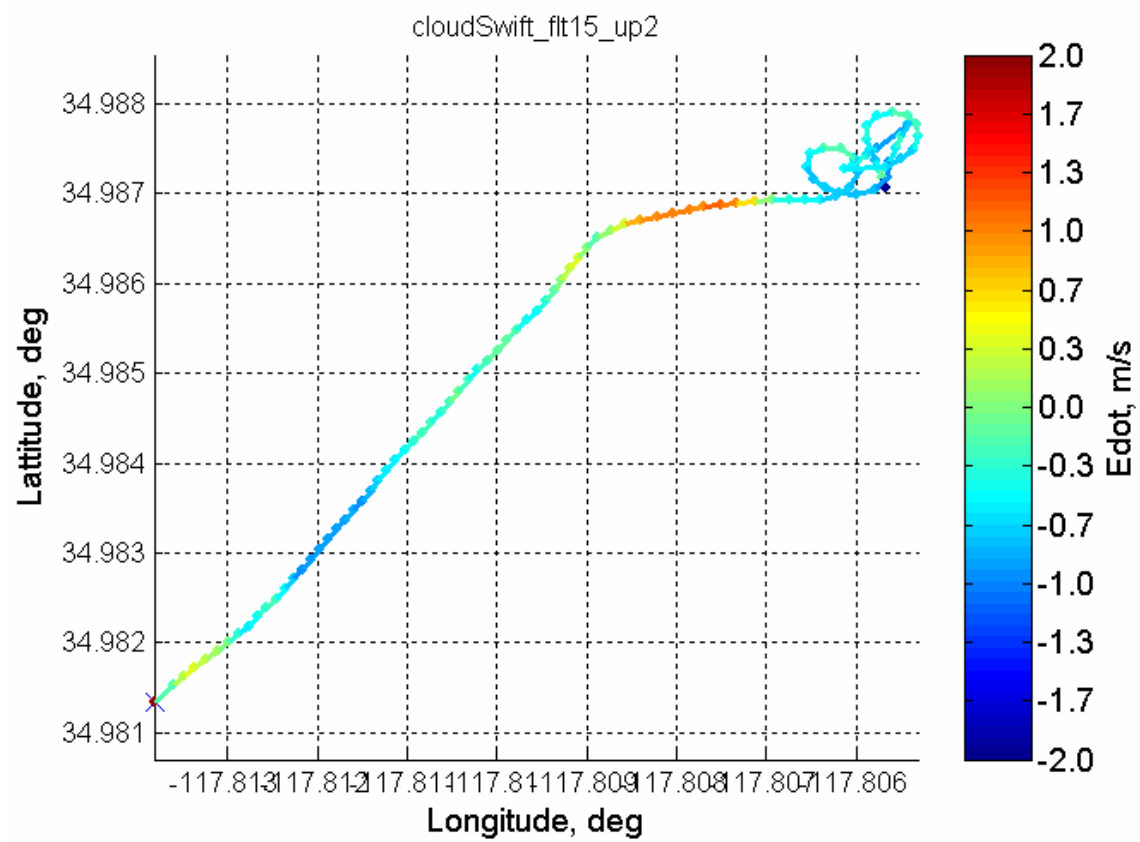


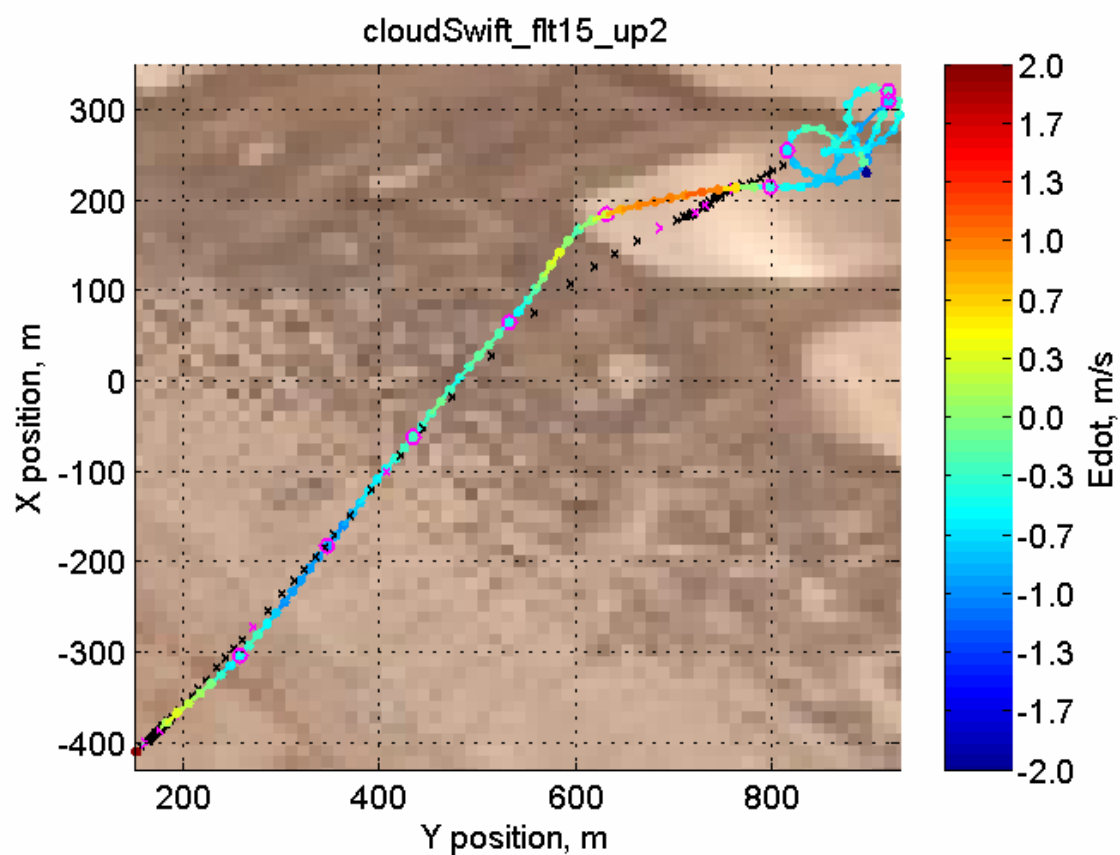
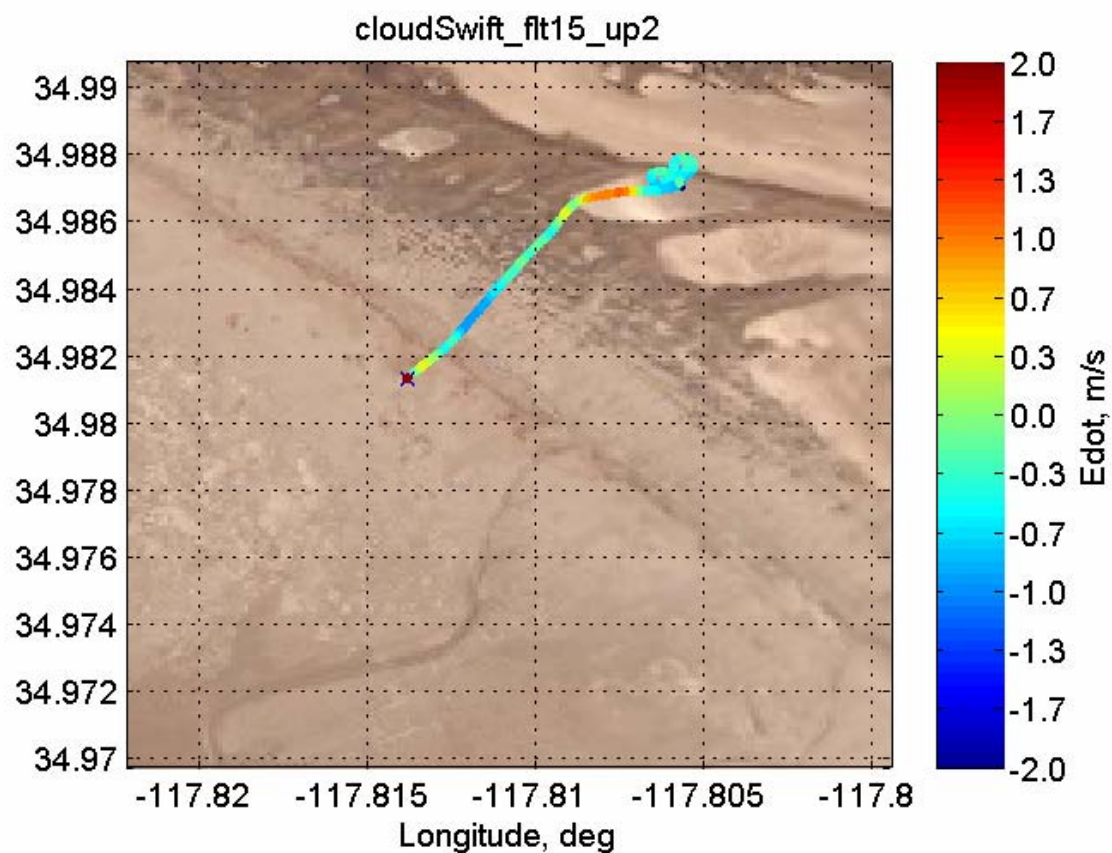


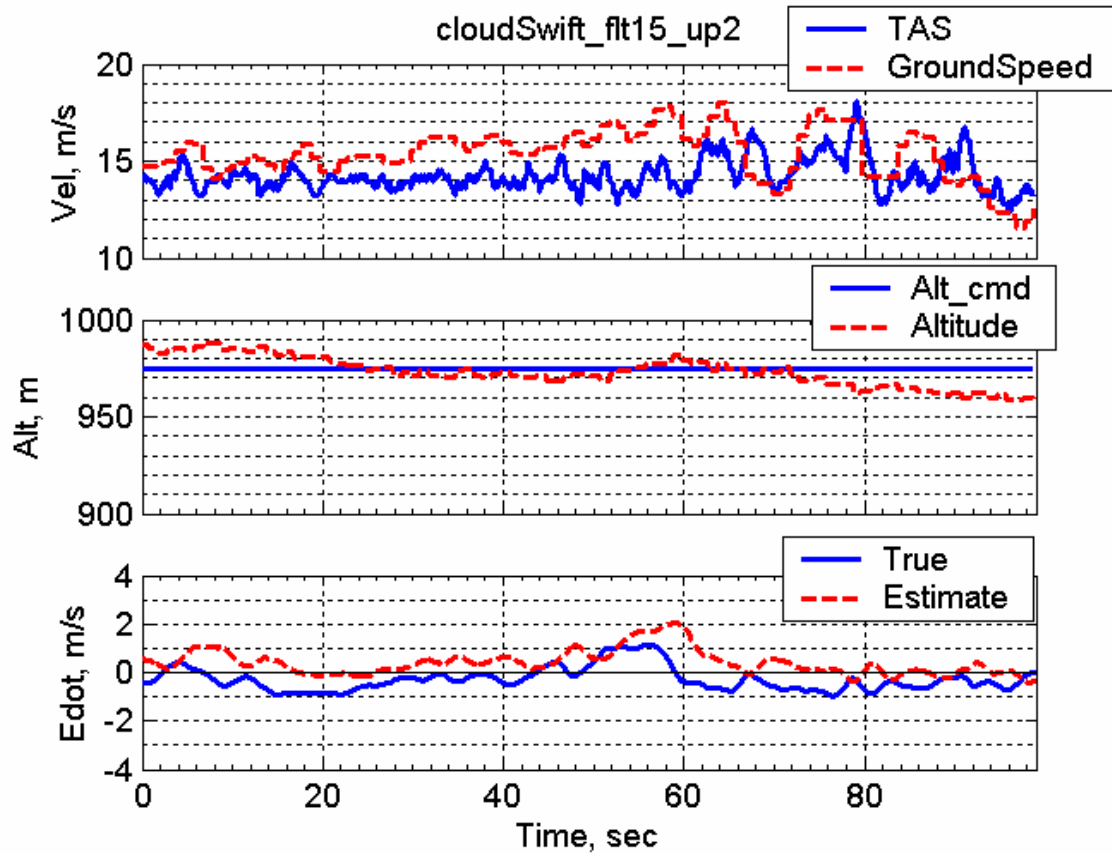
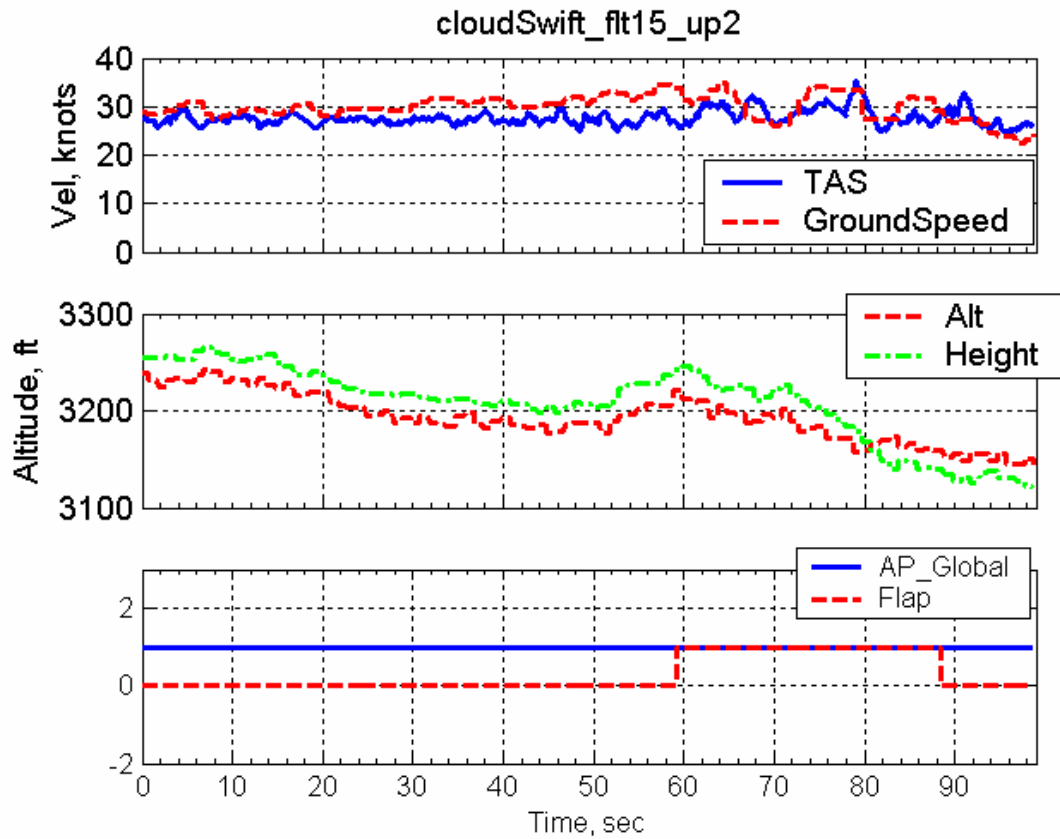


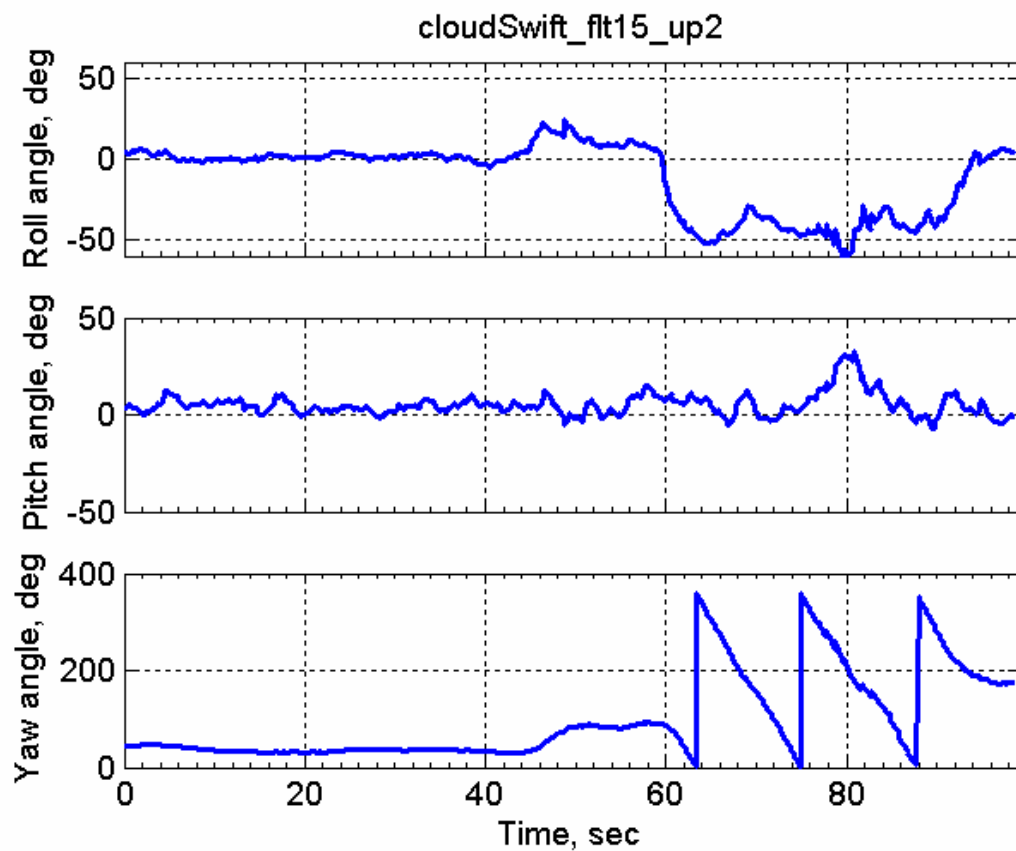
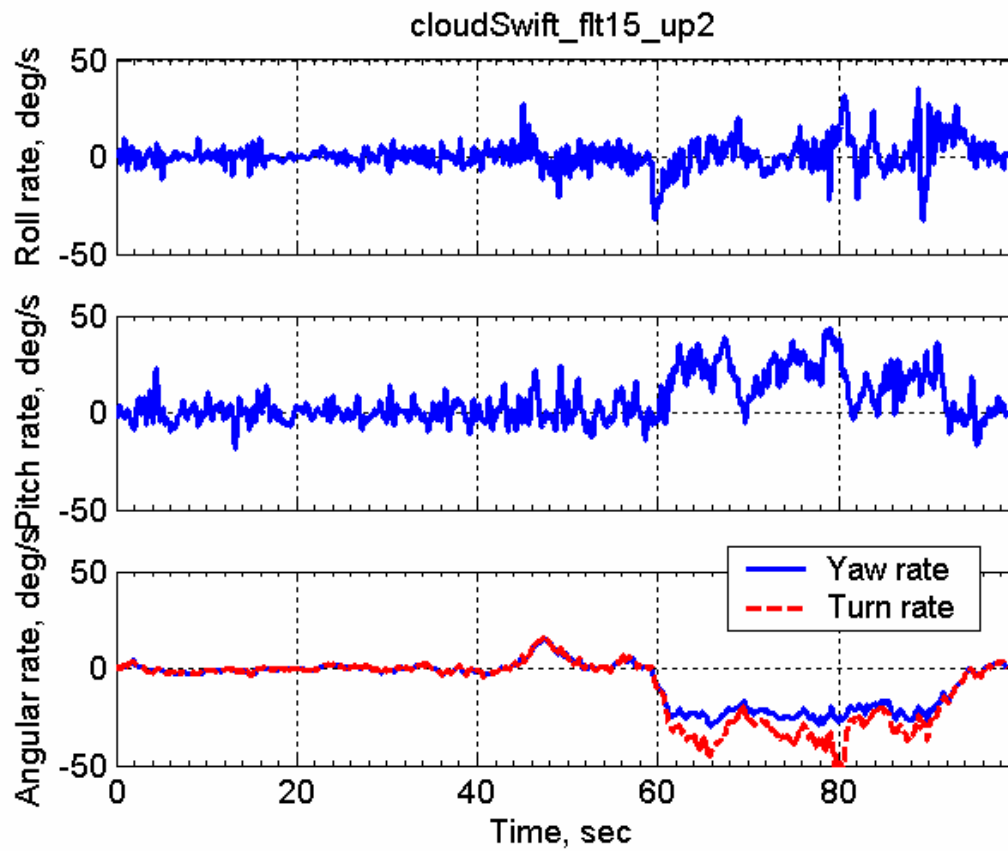


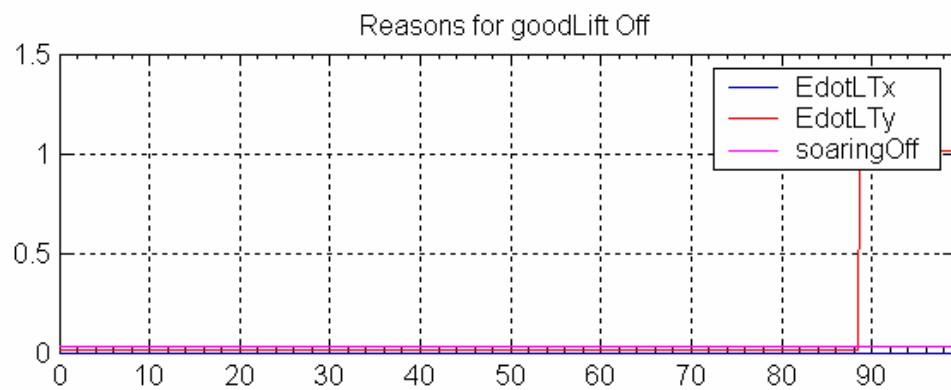
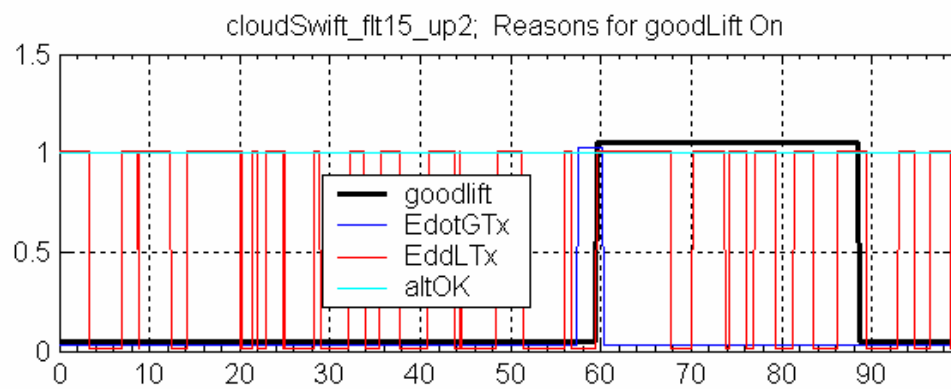
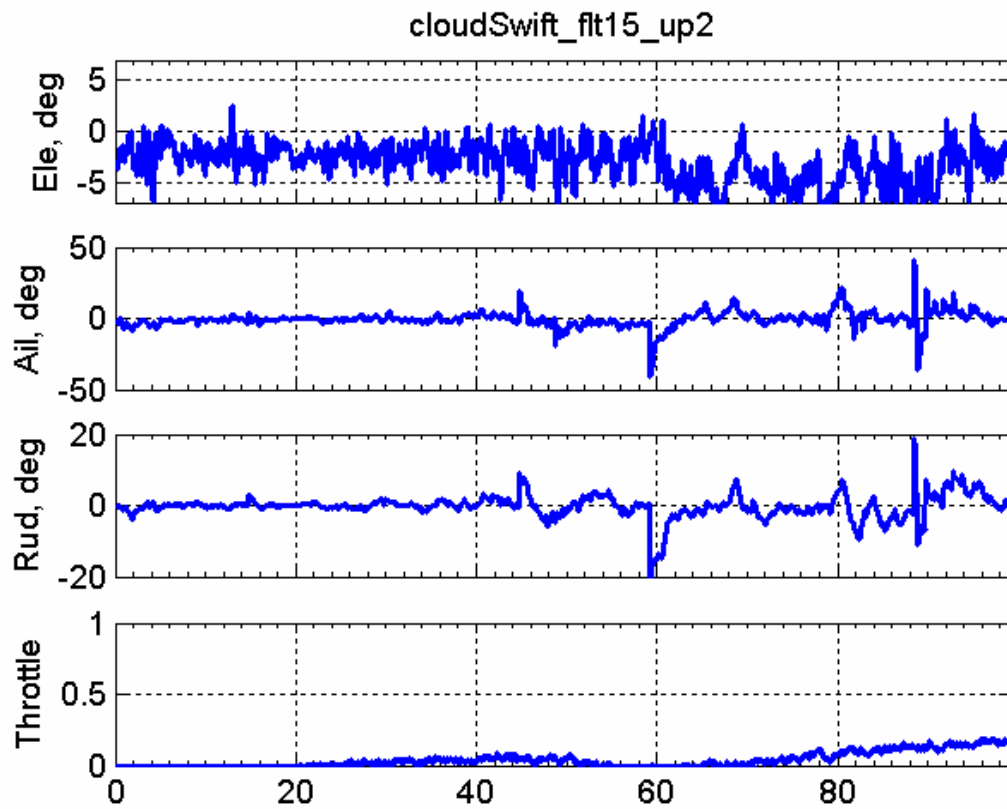
Flight 15, updraft 2

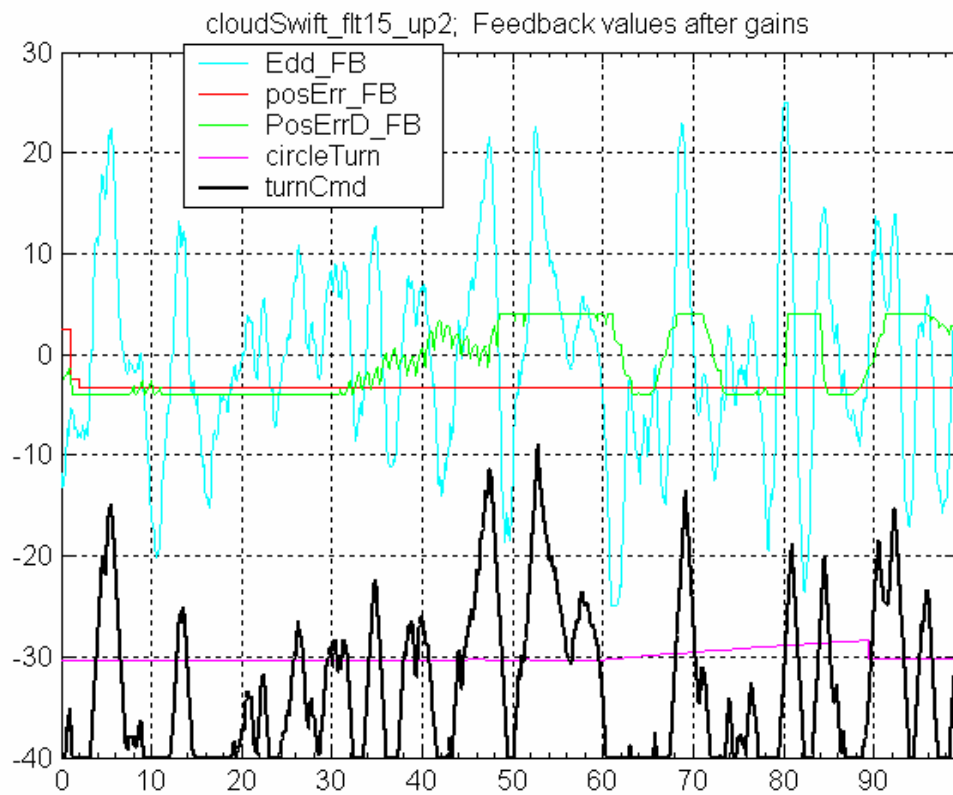
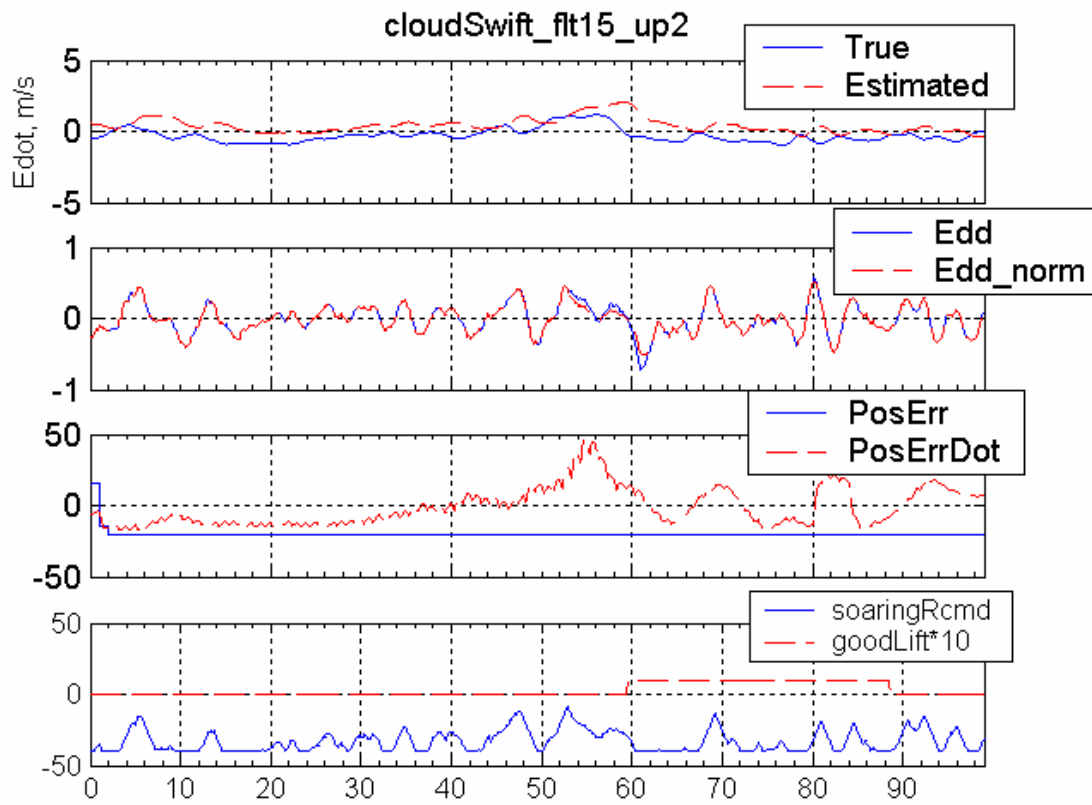






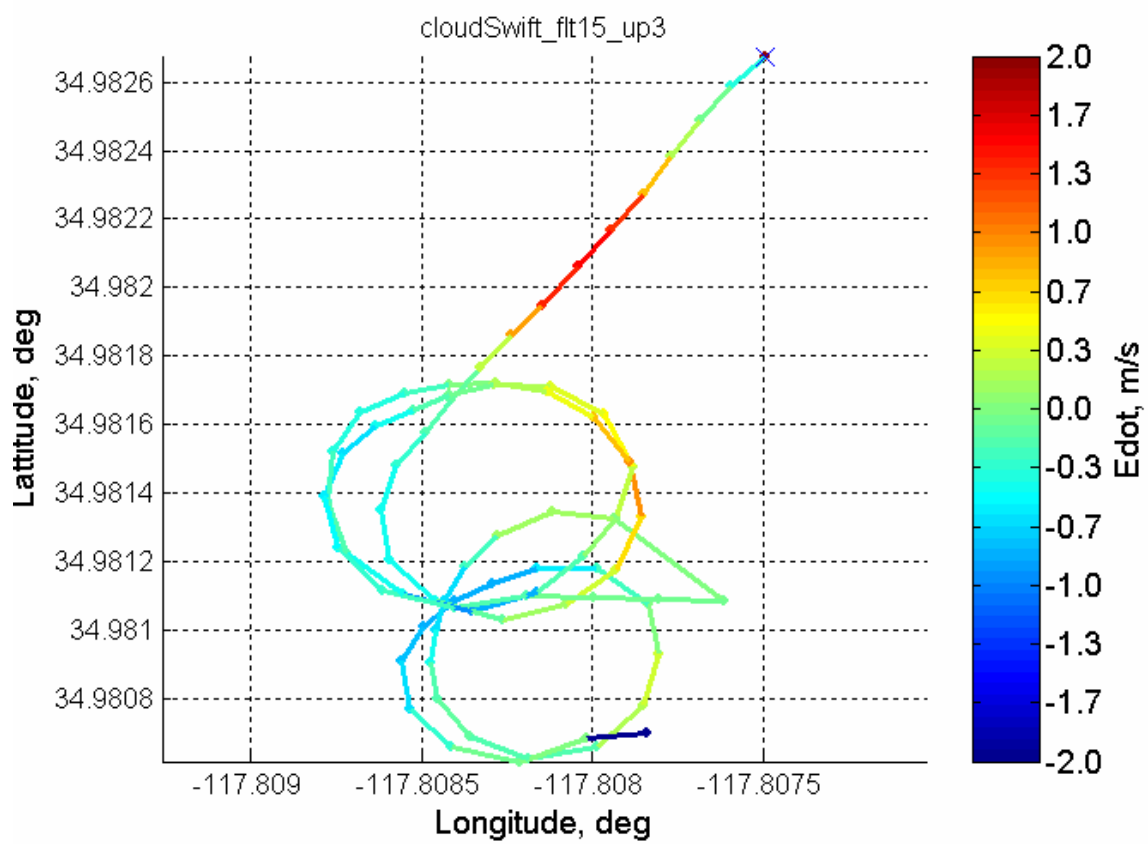


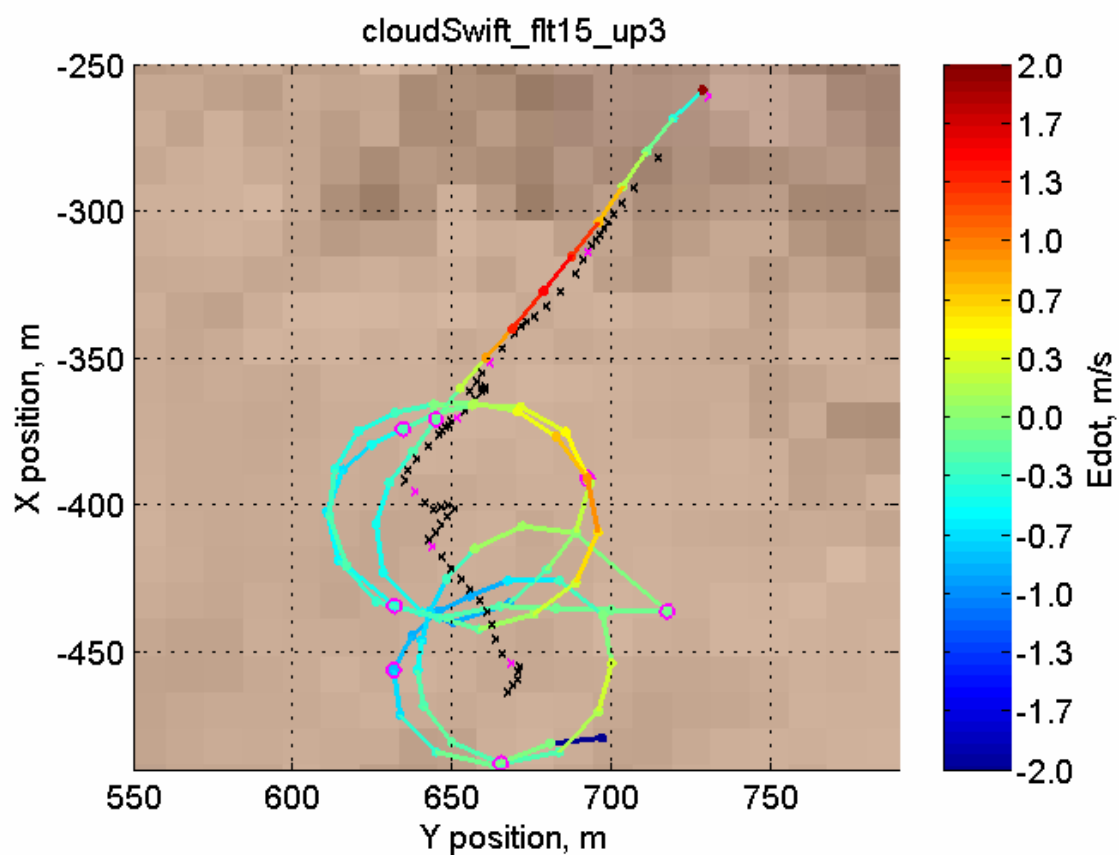
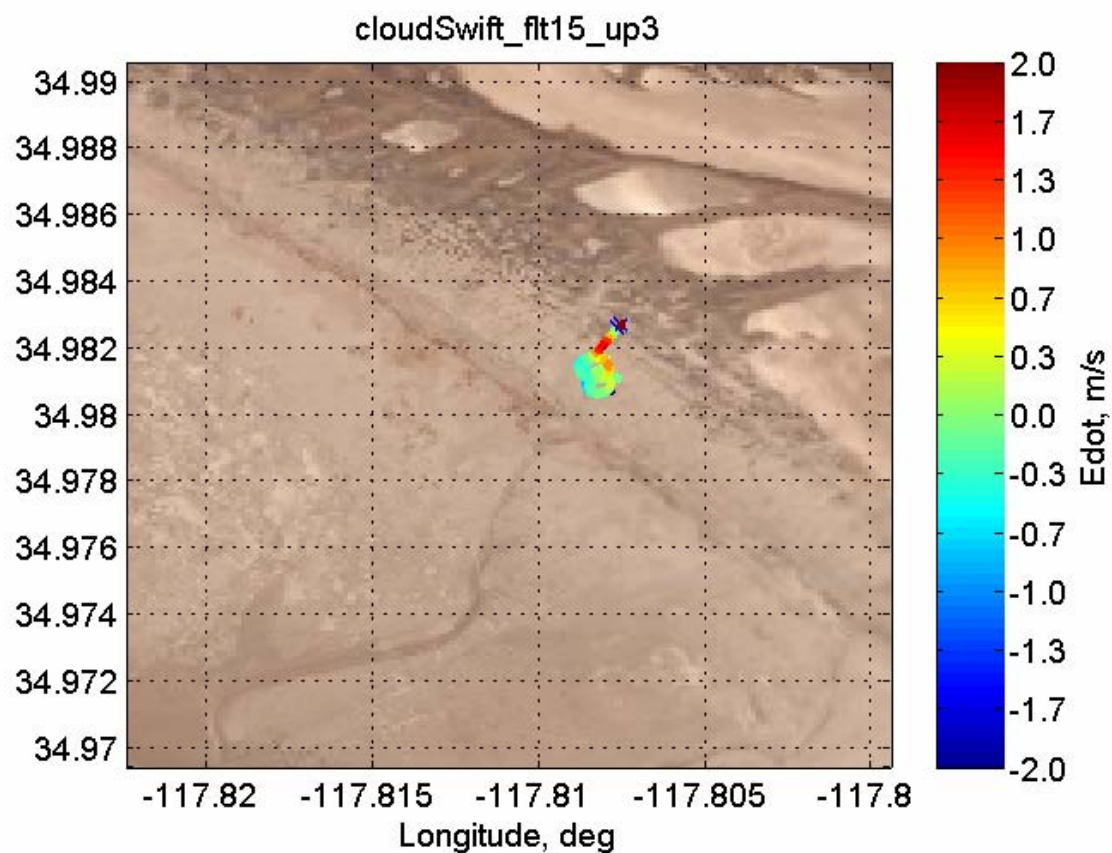


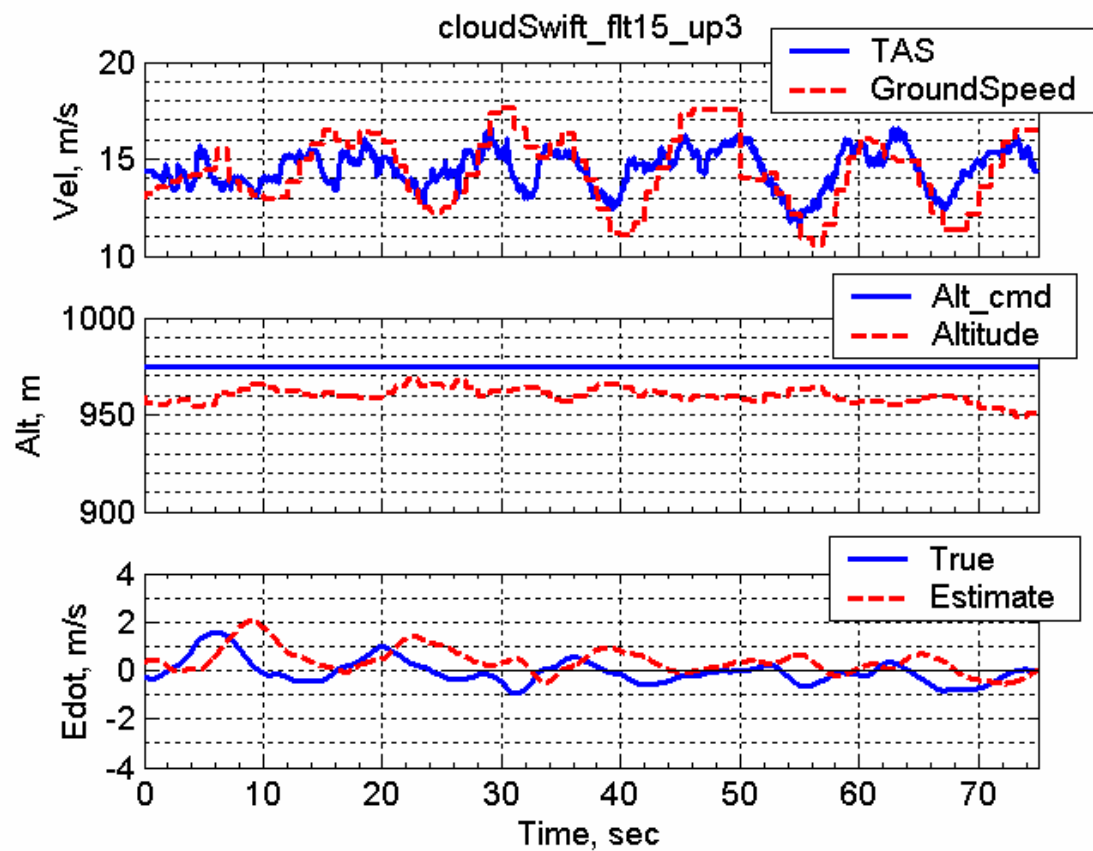
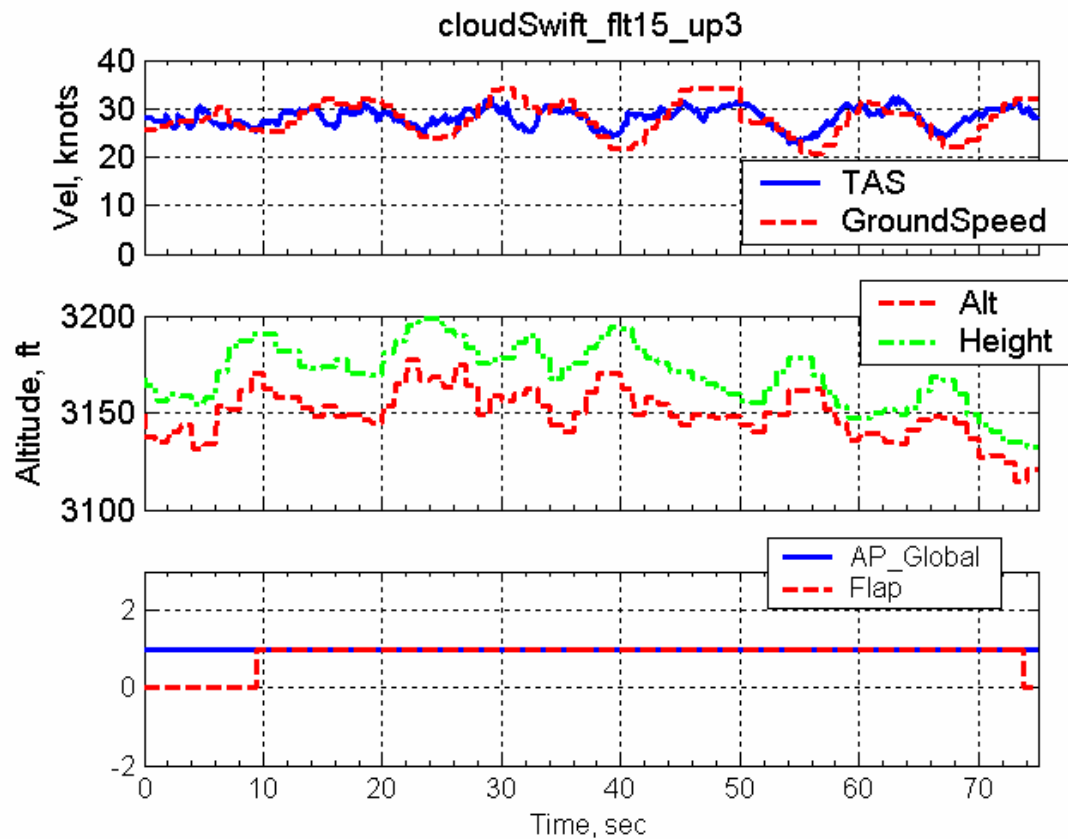


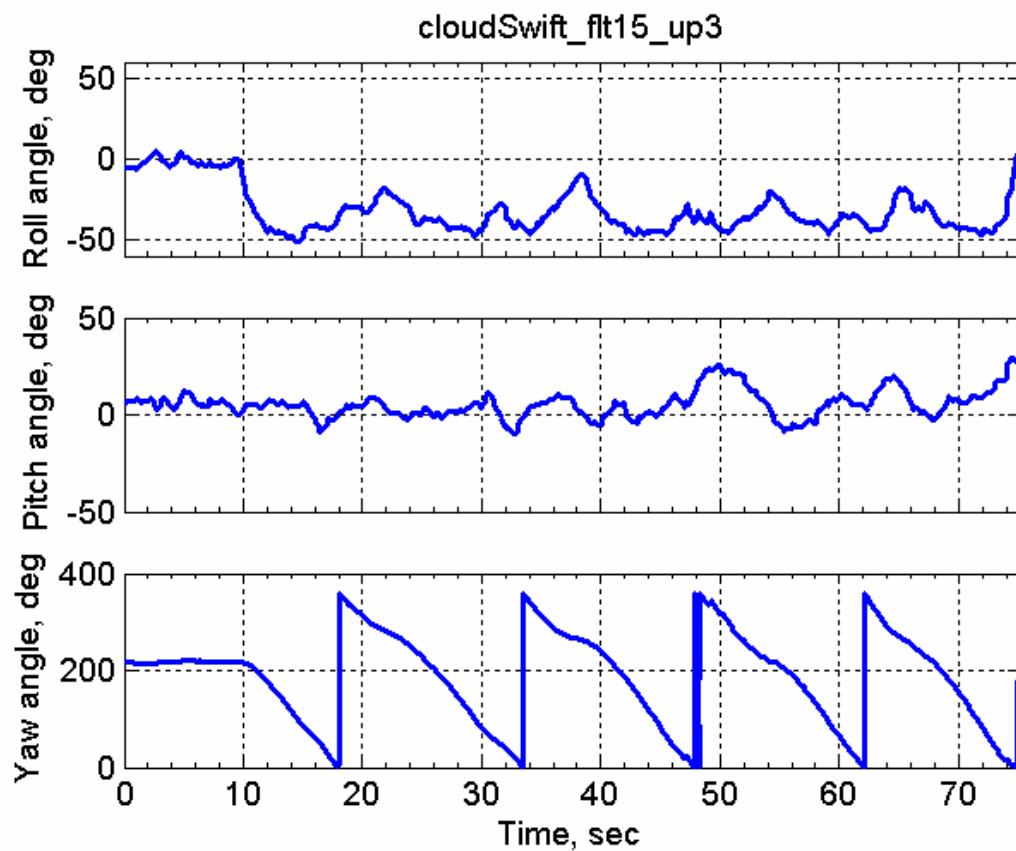
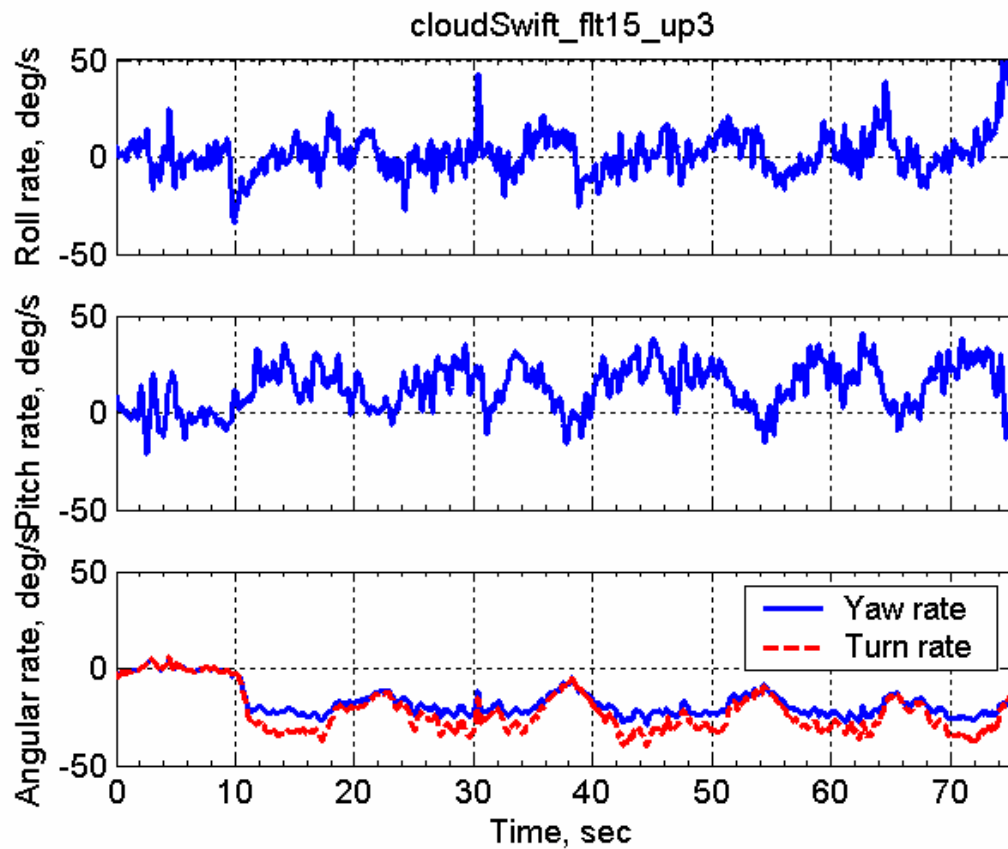
Flight 15, updraft 3

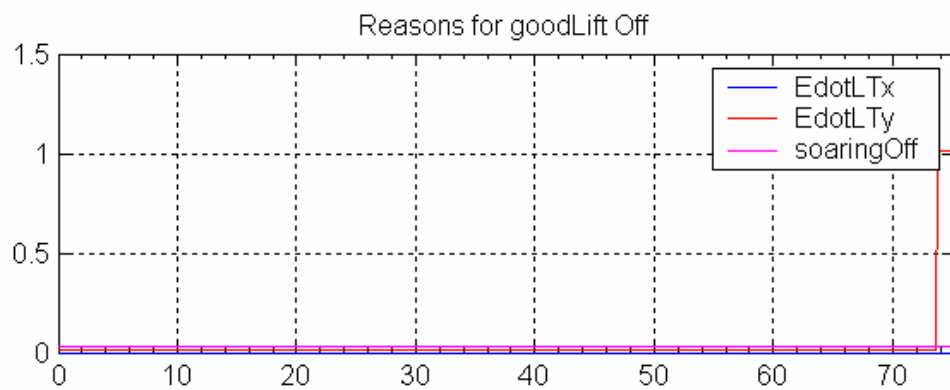
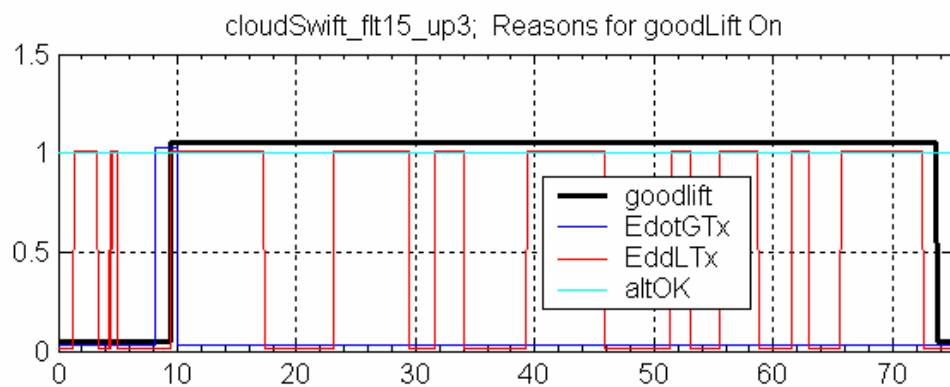
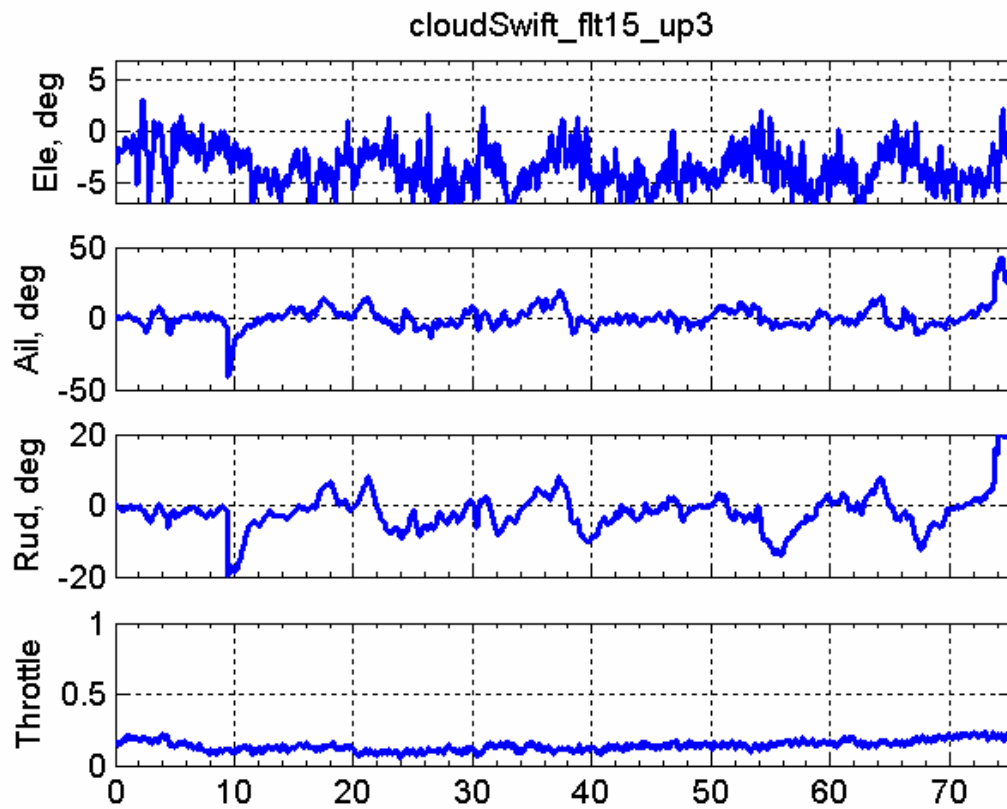
Aircraft did not center thermal well. Estimator seems to be working. posErr and Edd delay caused poor centering.

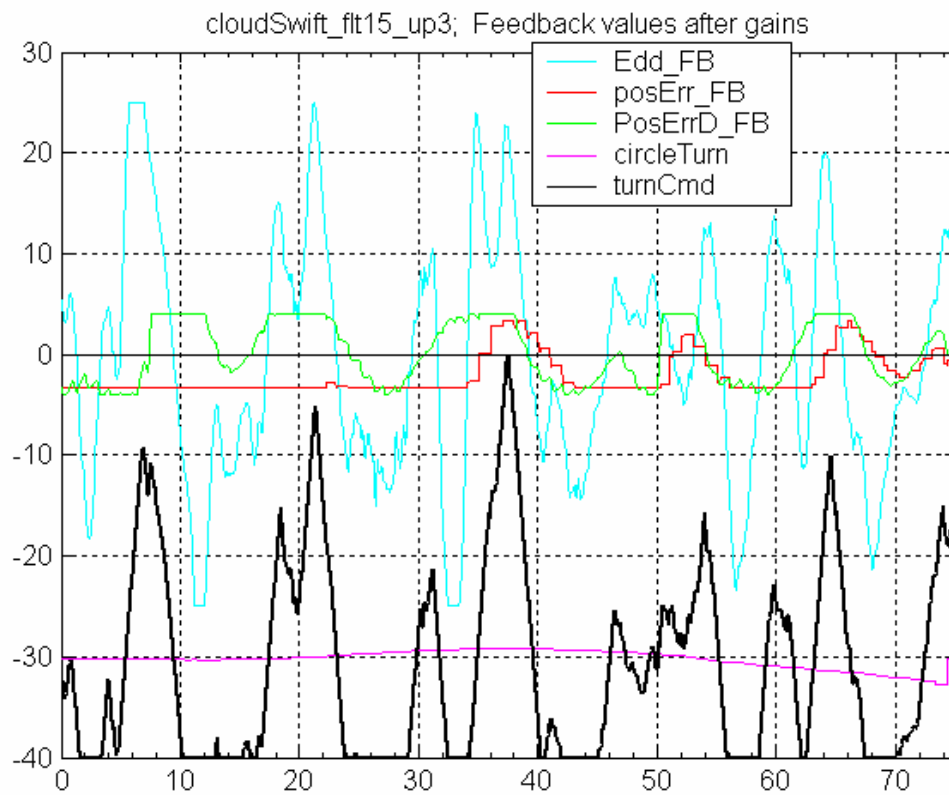
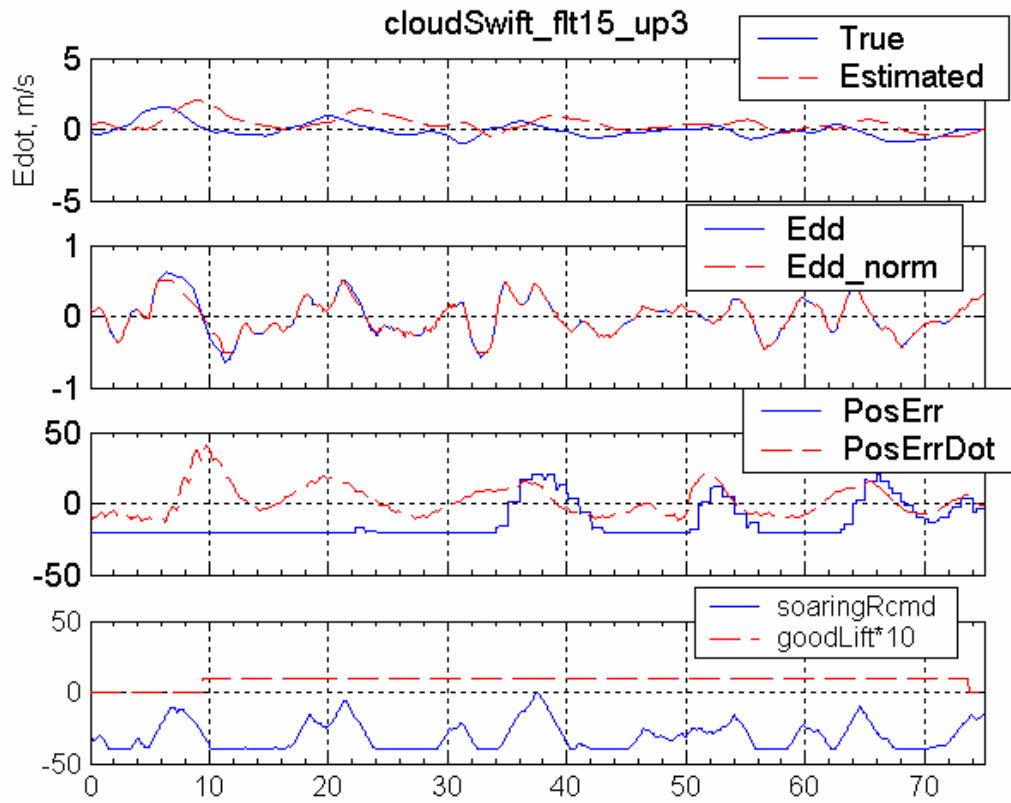






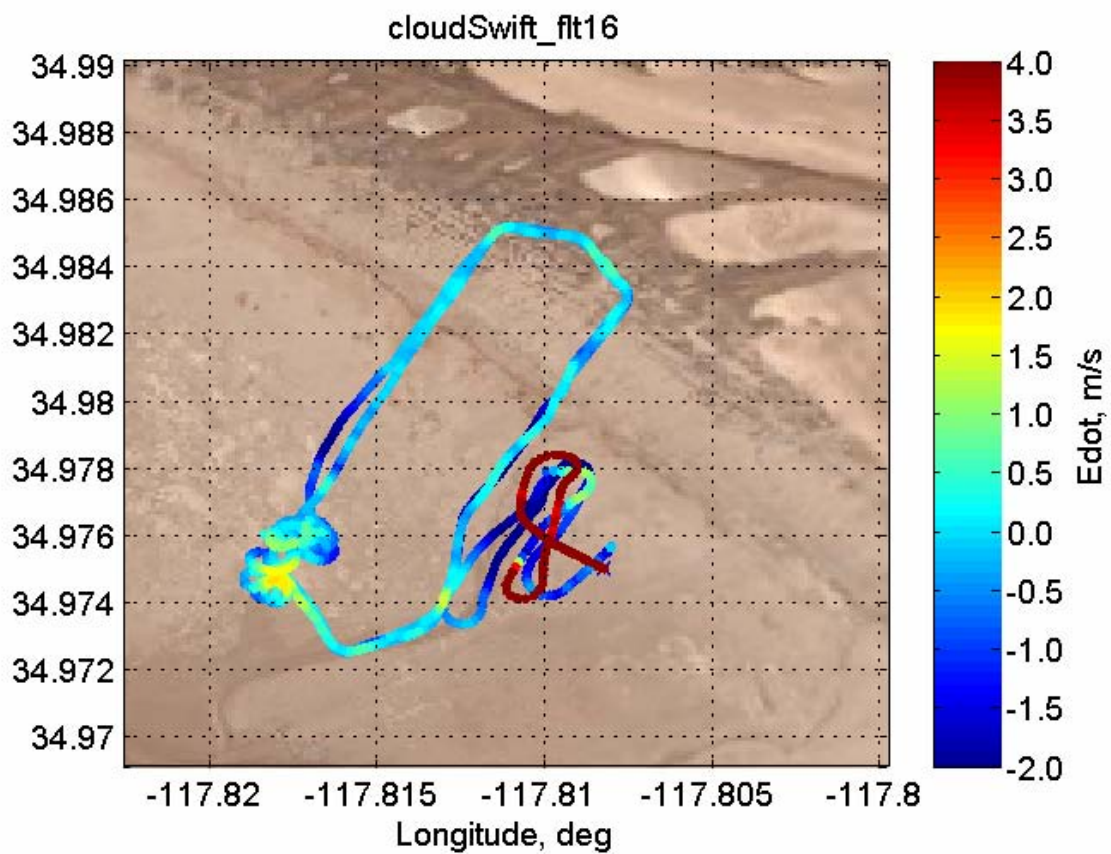


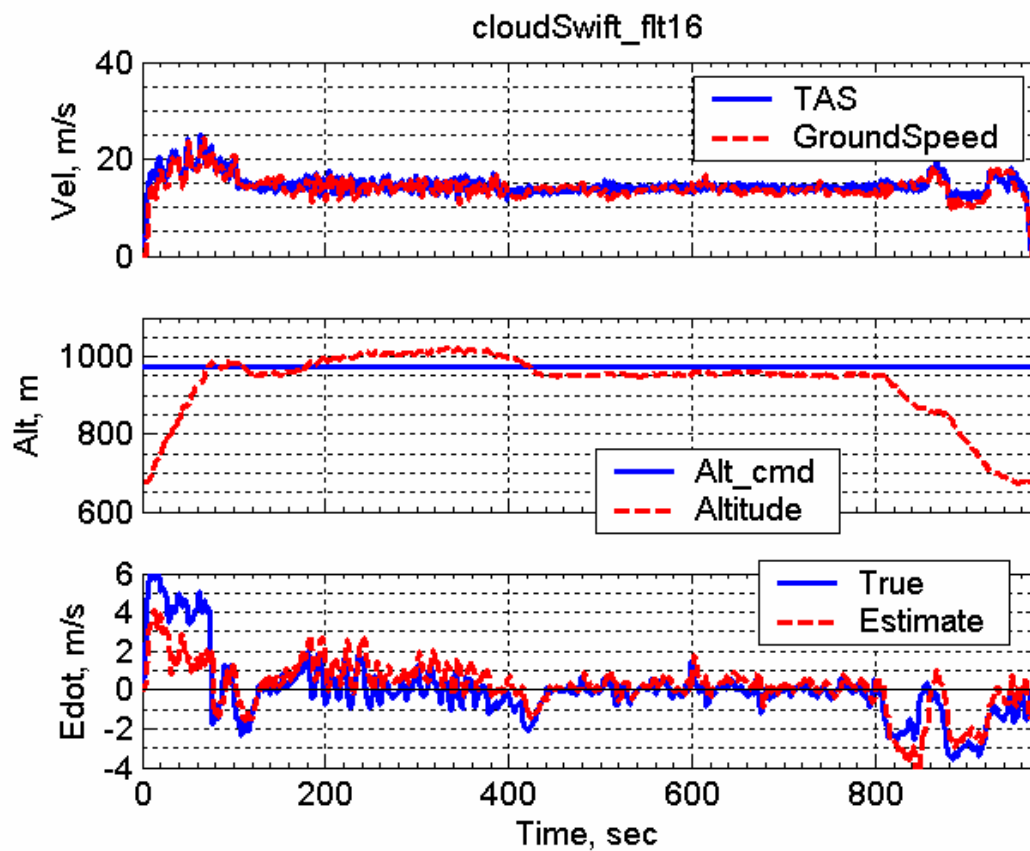
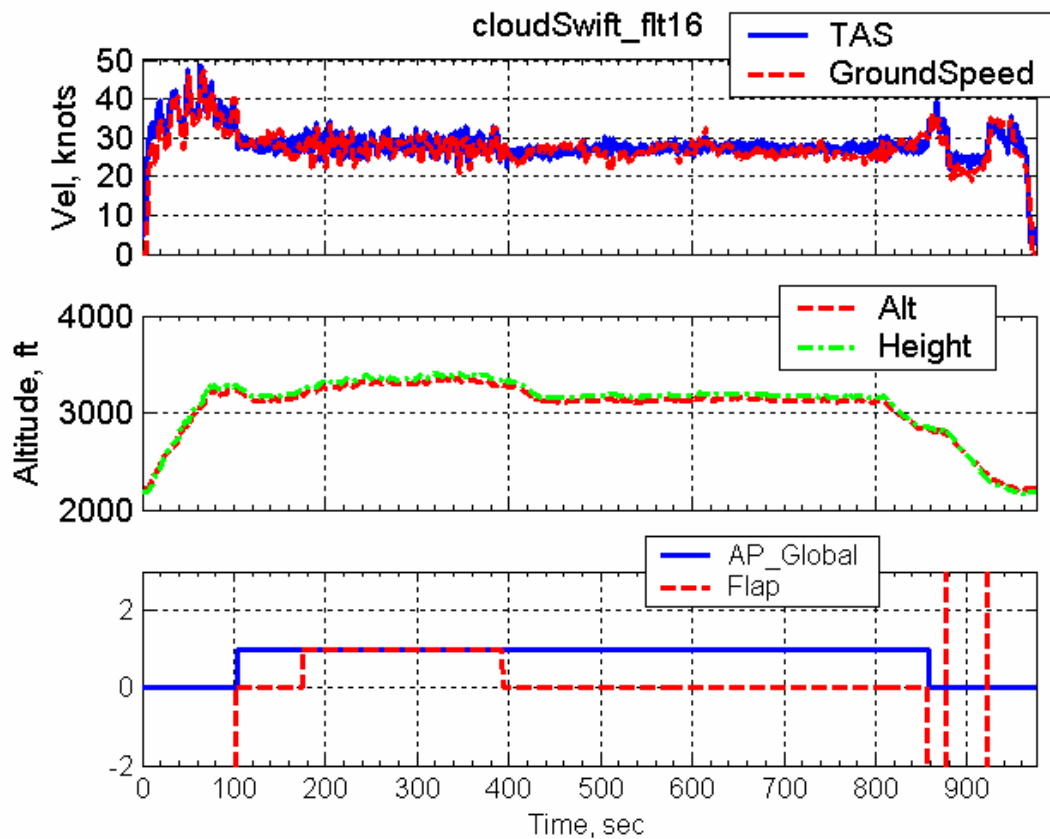


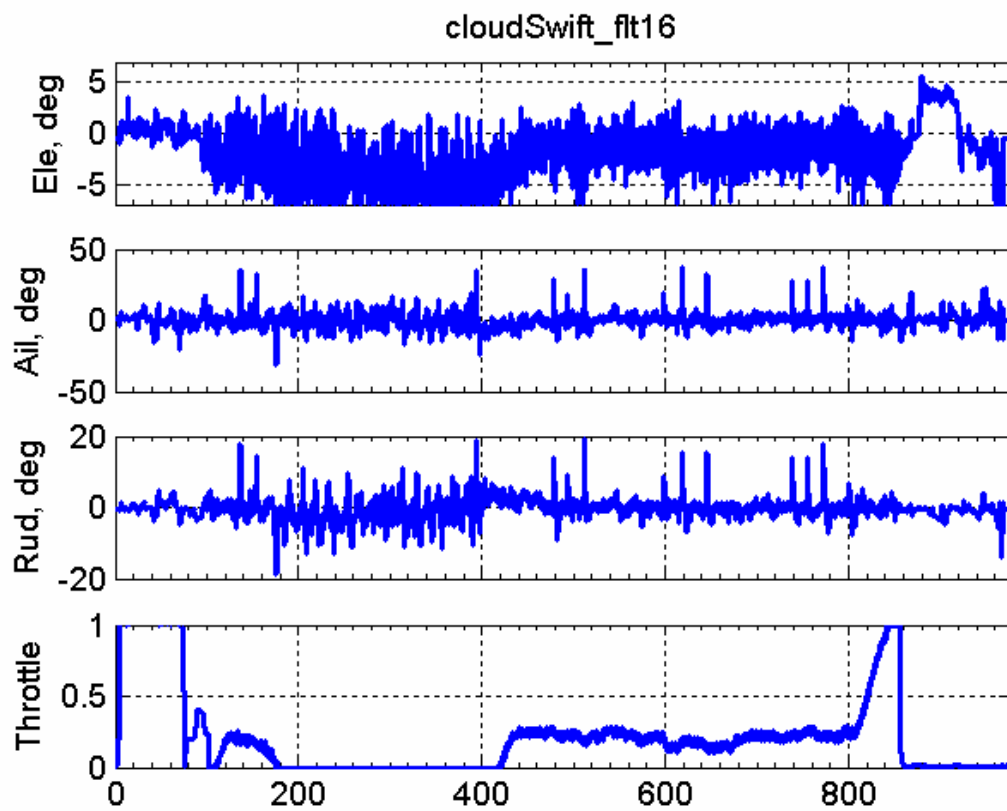
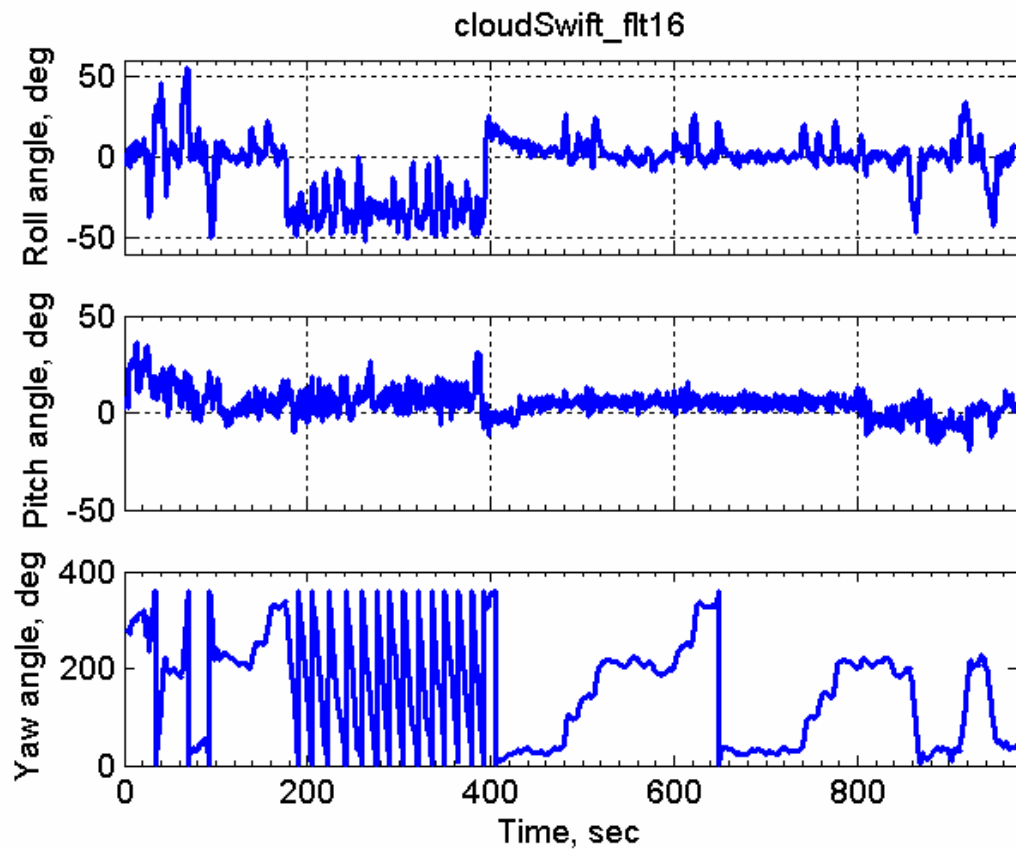


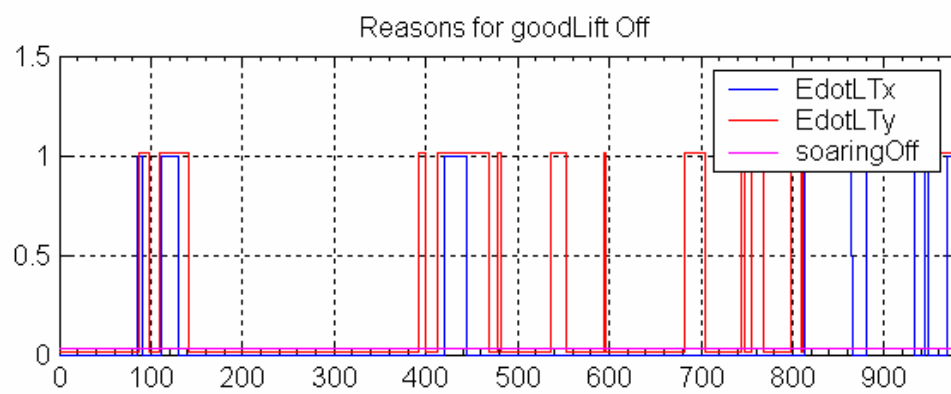
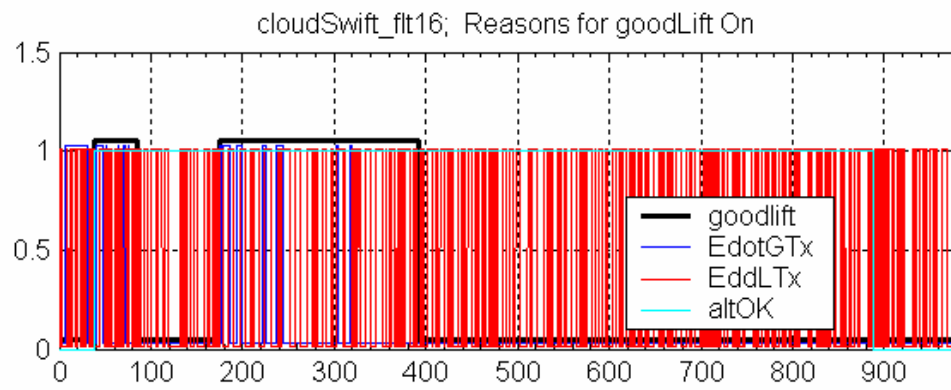
Flight 16

Two soaring mode engagements. Note throttle command ramp up at end of flight, indicating a drop in motor battery voltage.



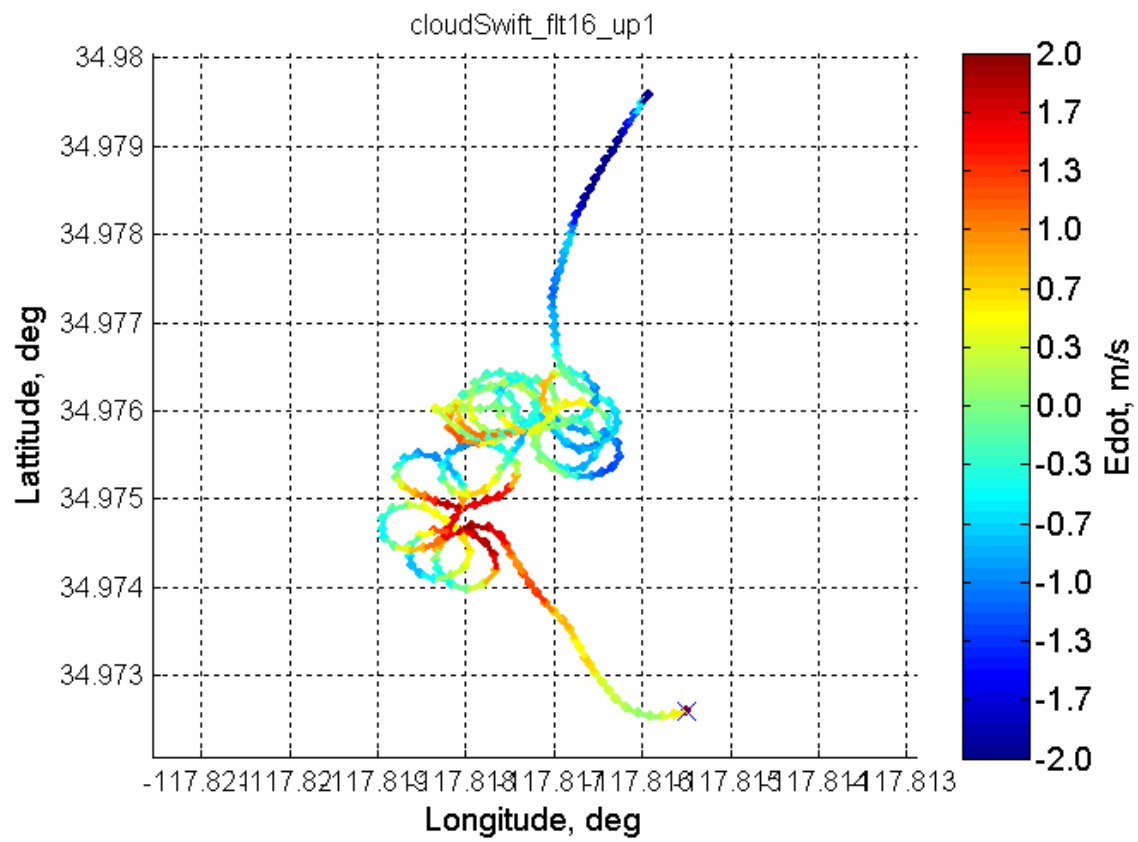


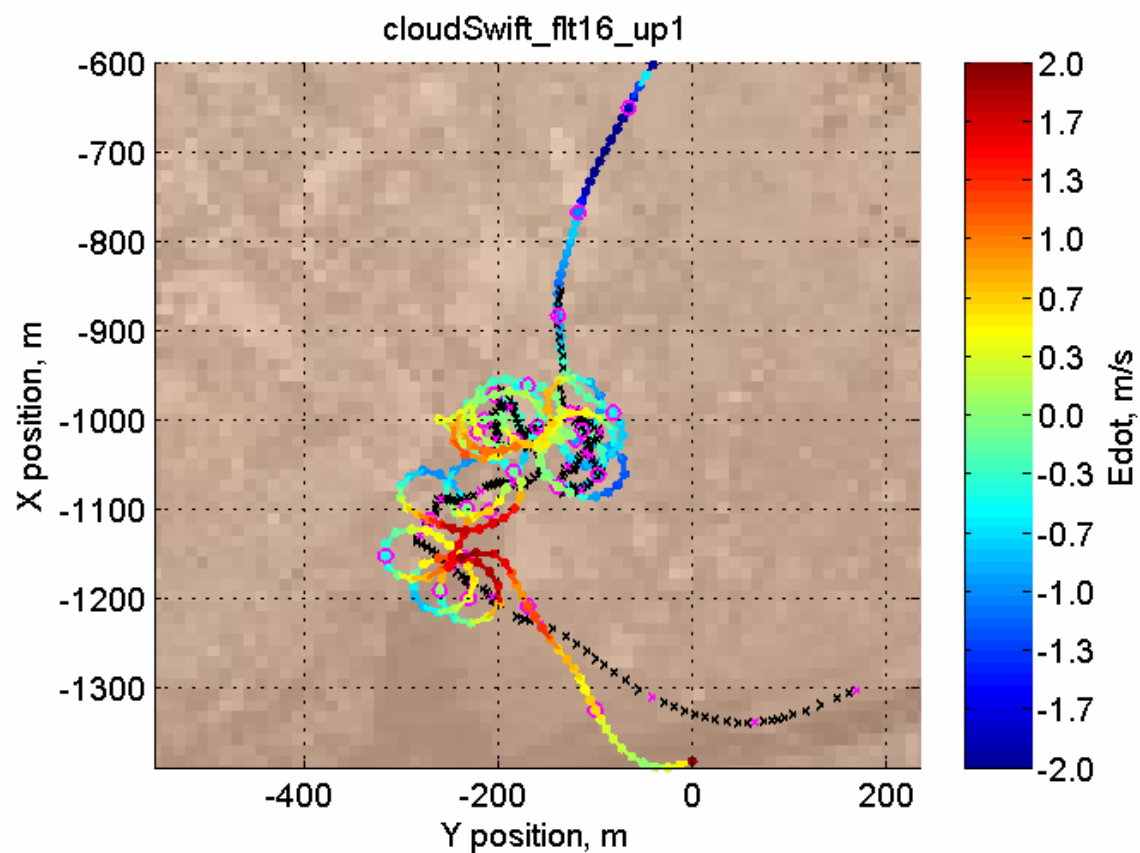
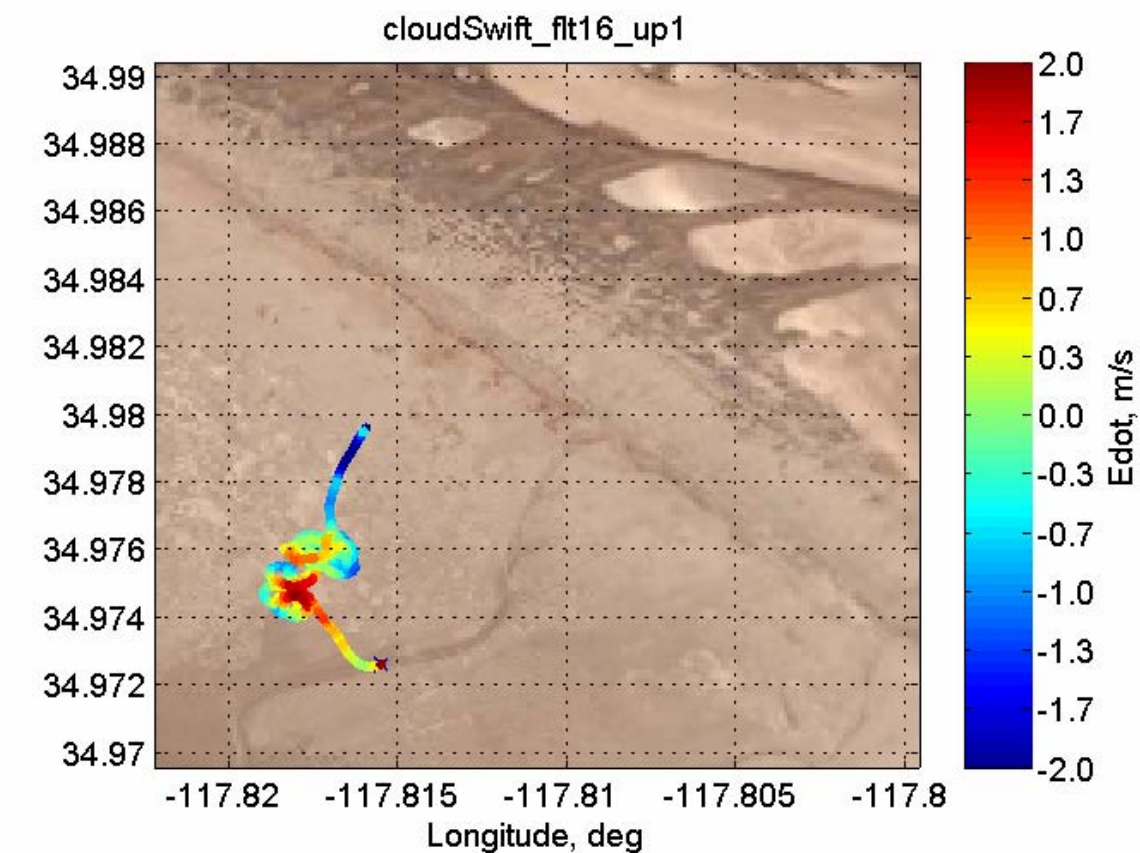


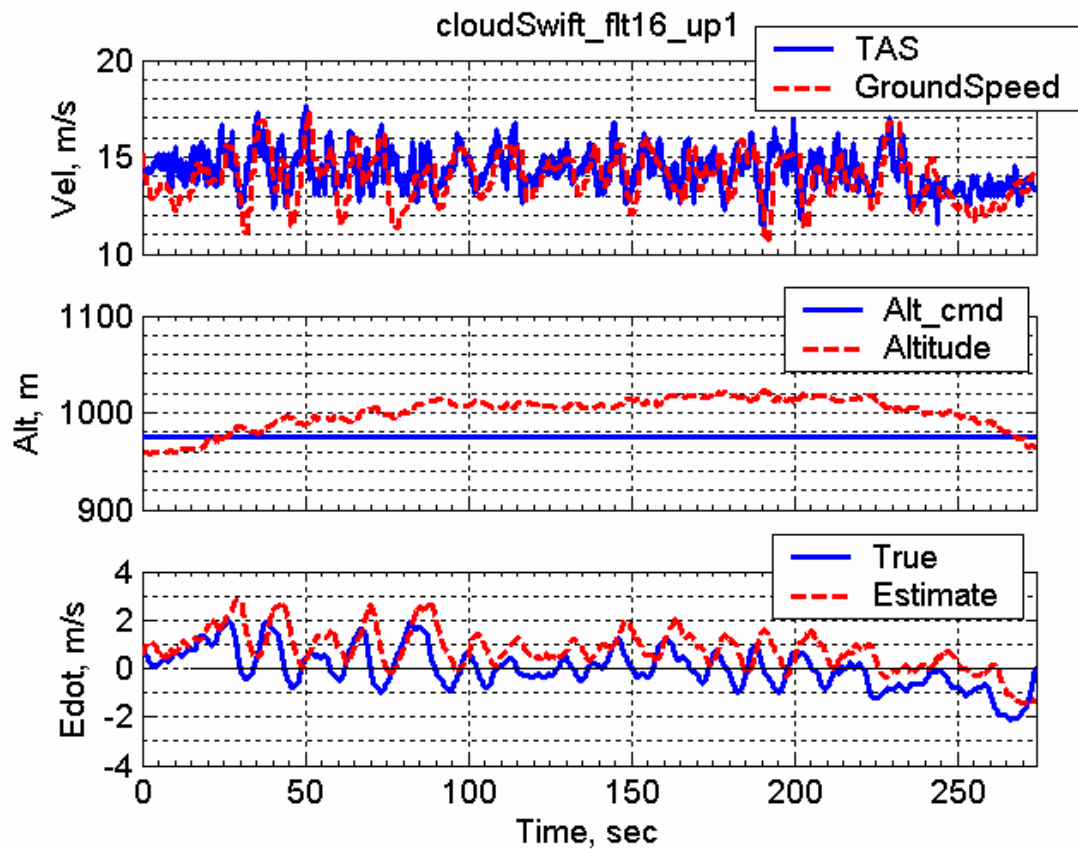
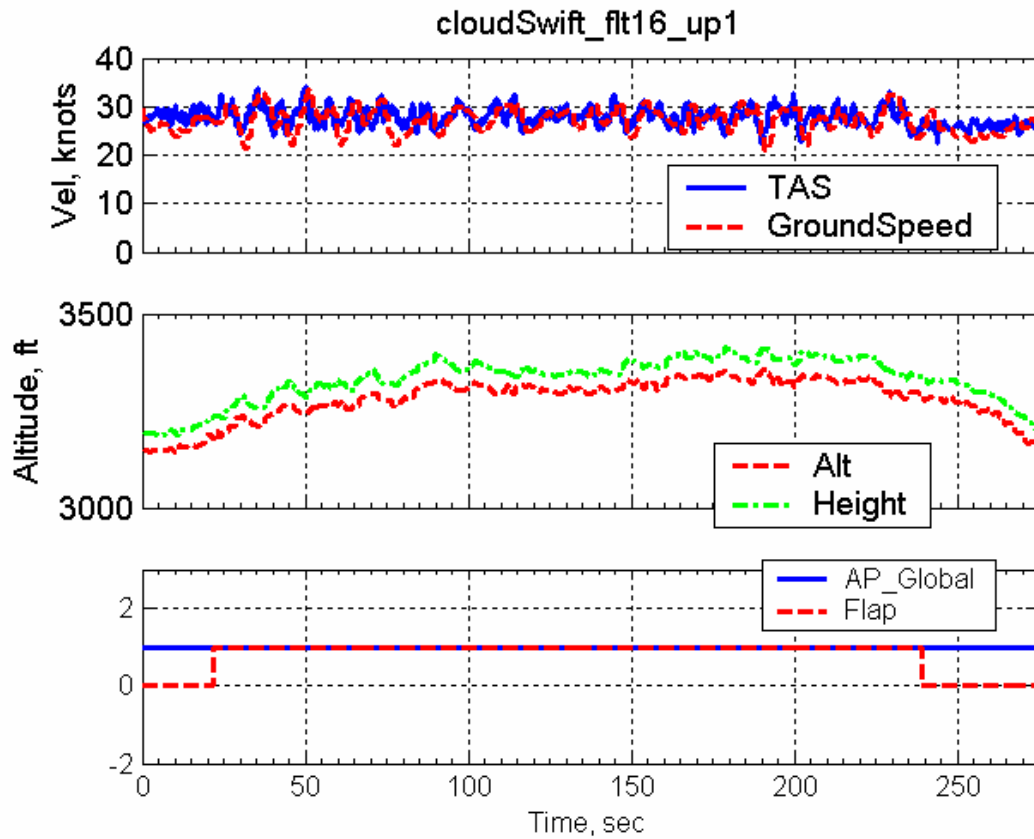


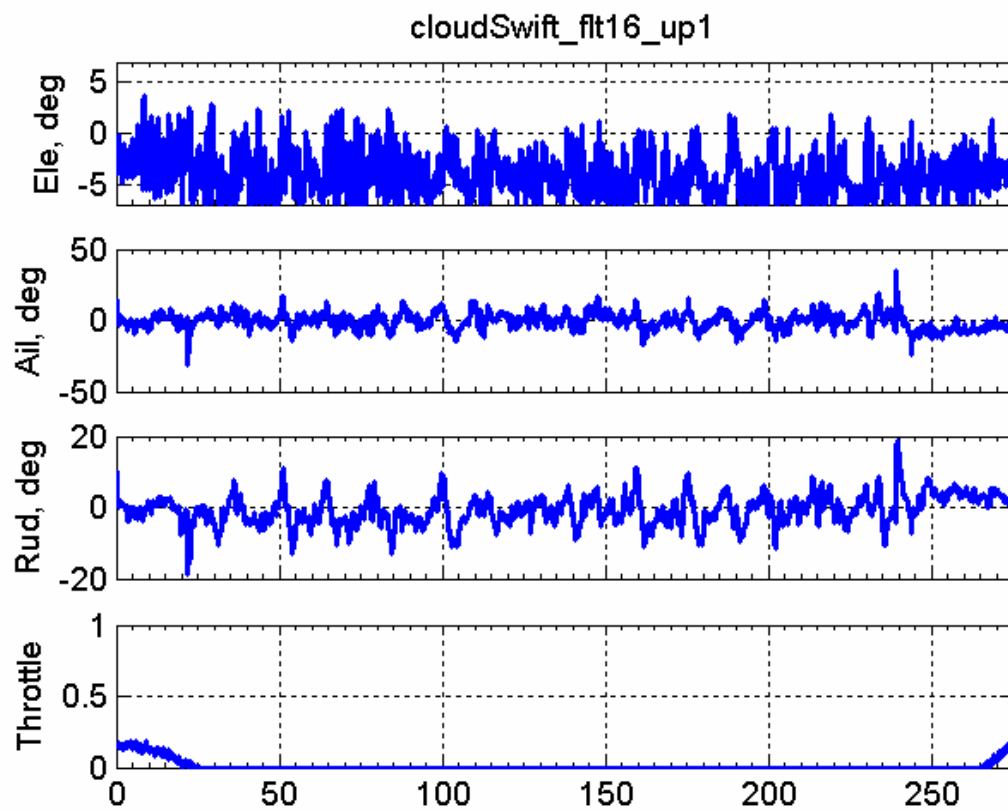
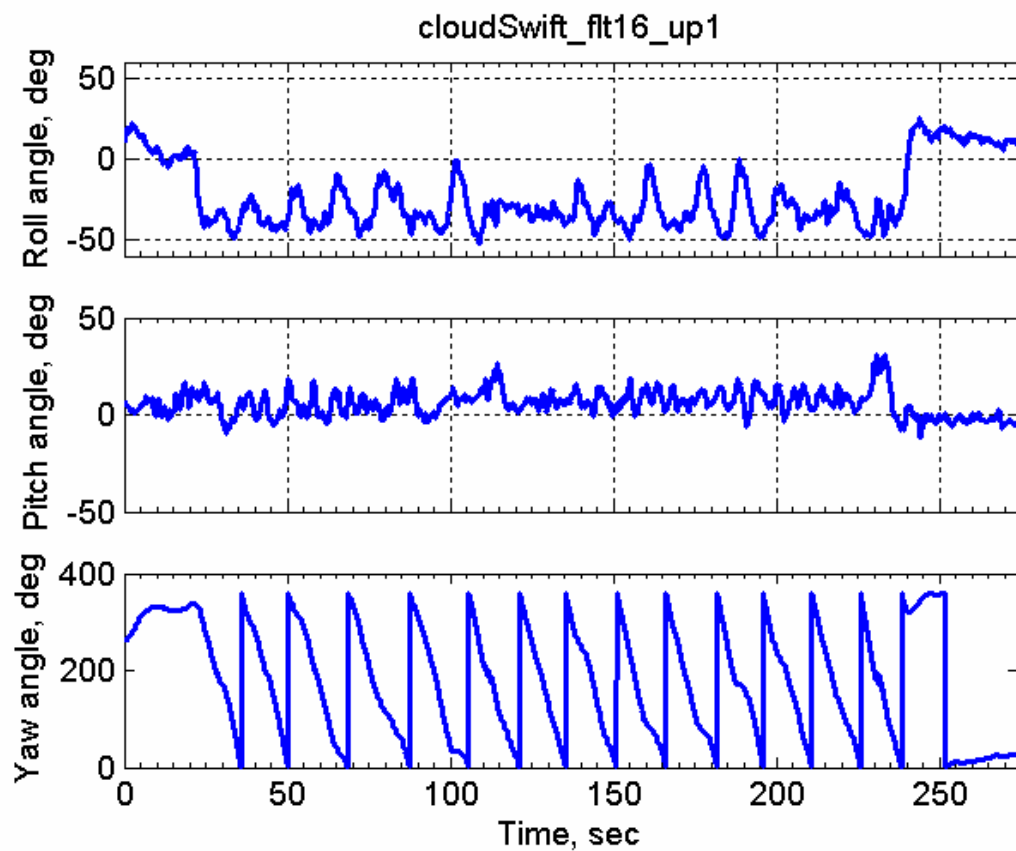
Flight 16, updraft 1

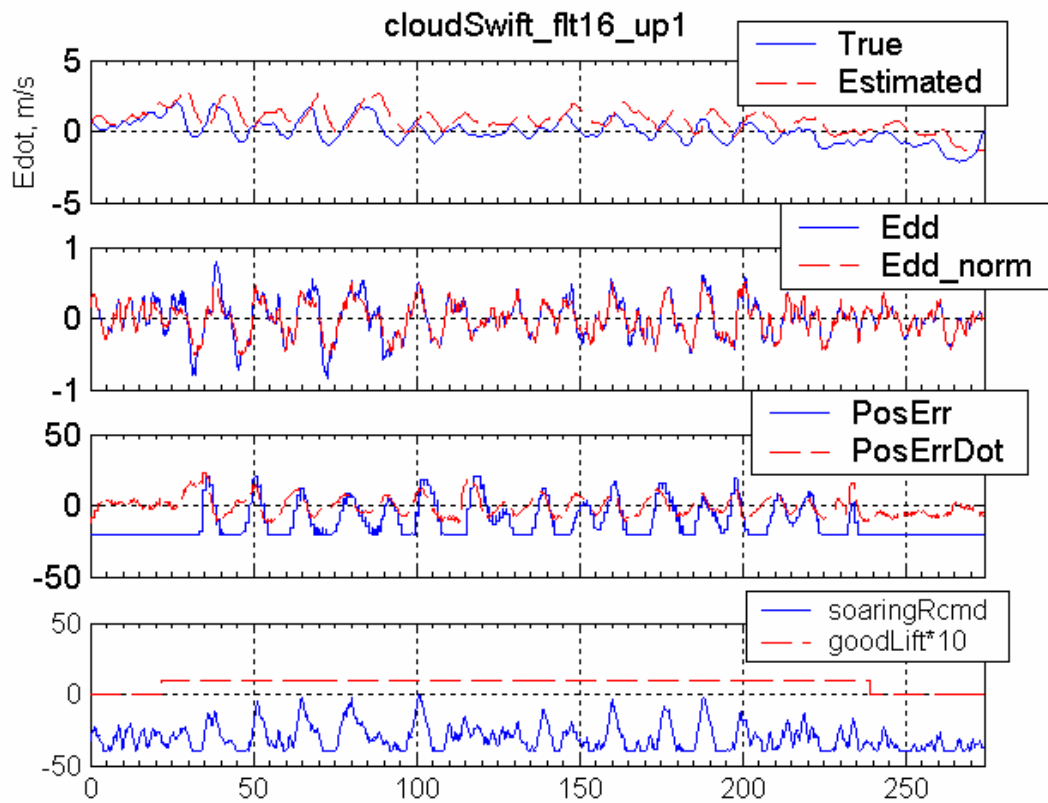
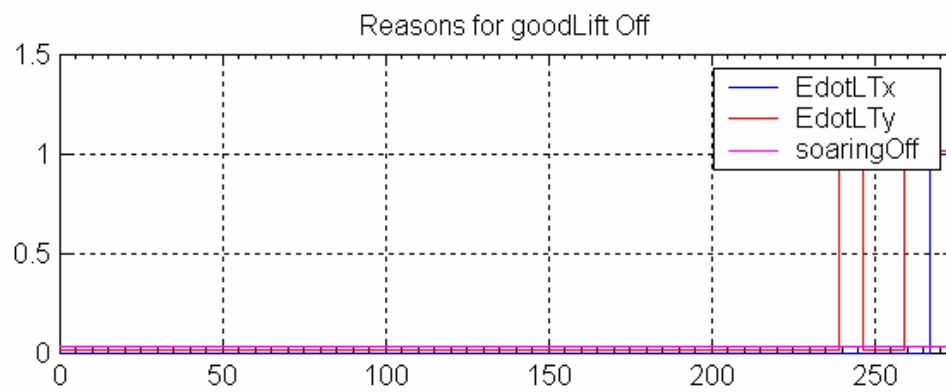
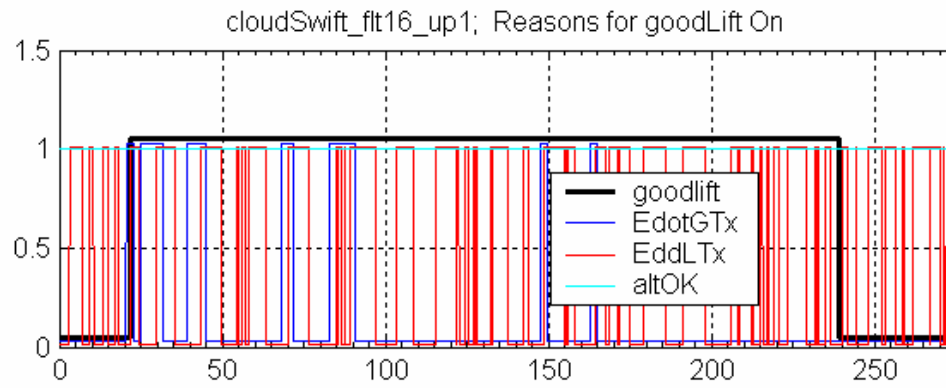
Reduced posErrD gain made centering worse. Drift calculation too high due to poor centering.

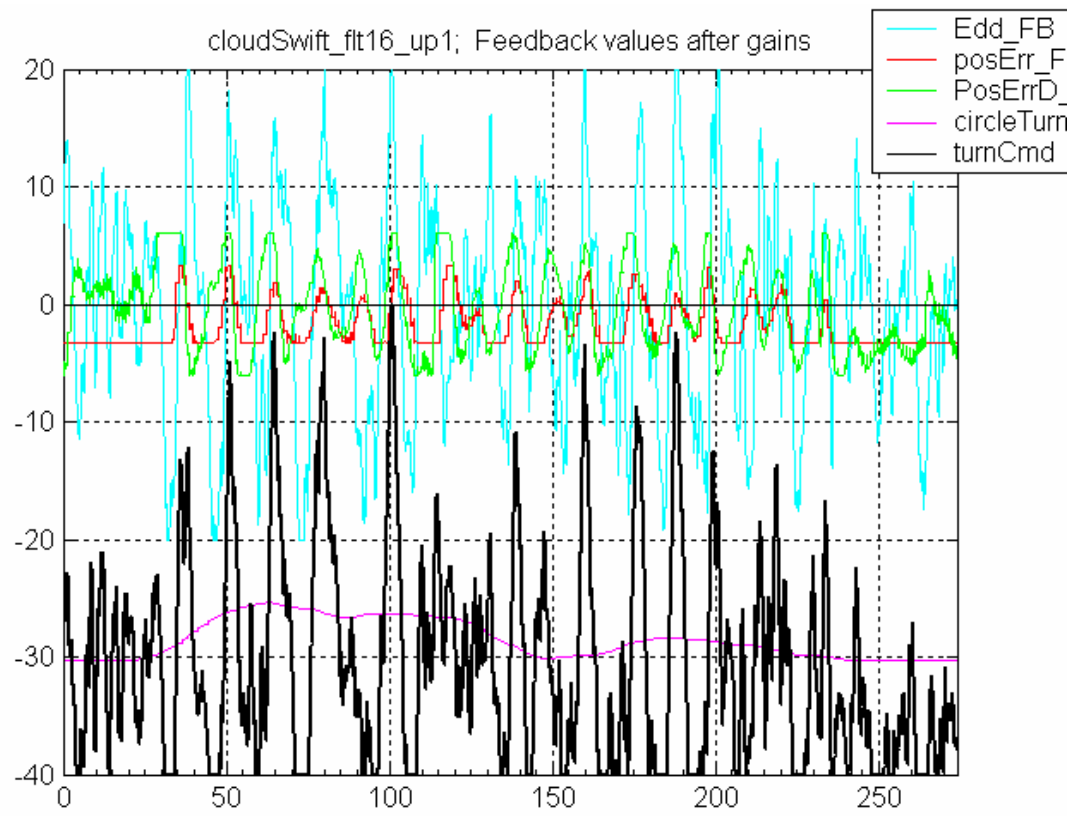






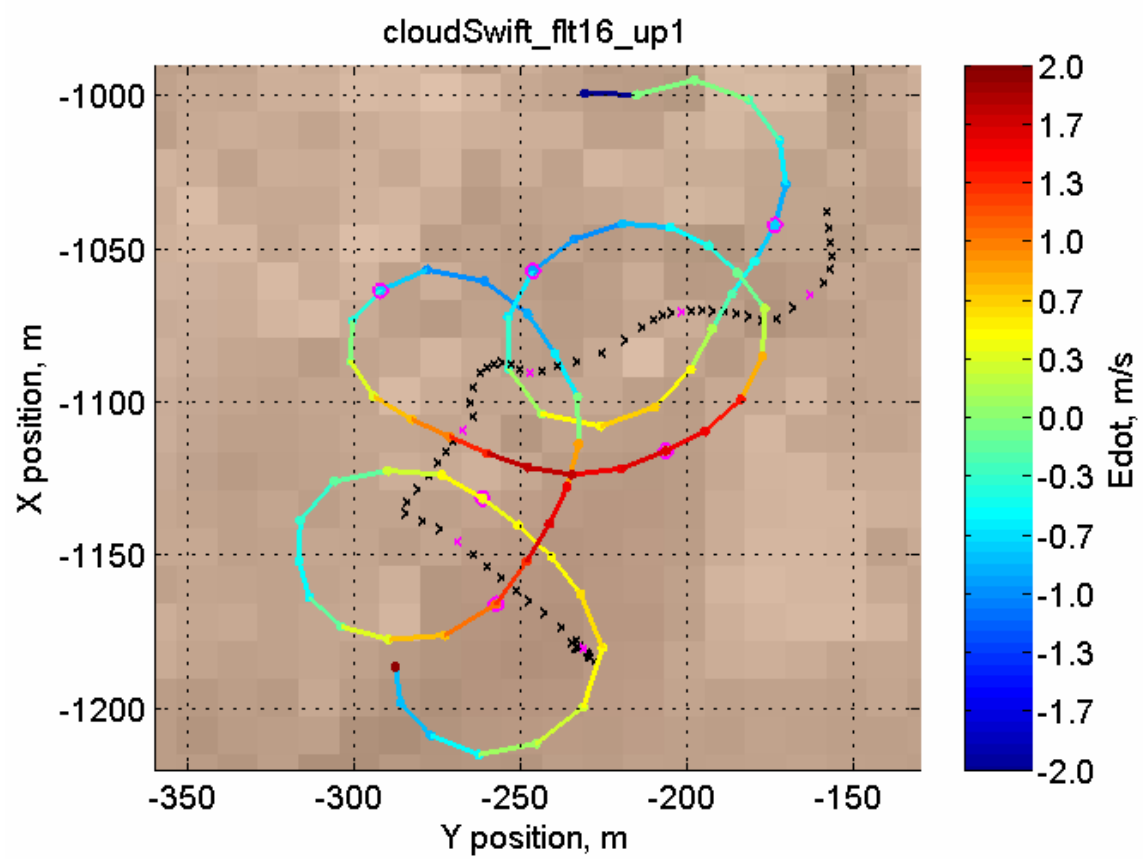


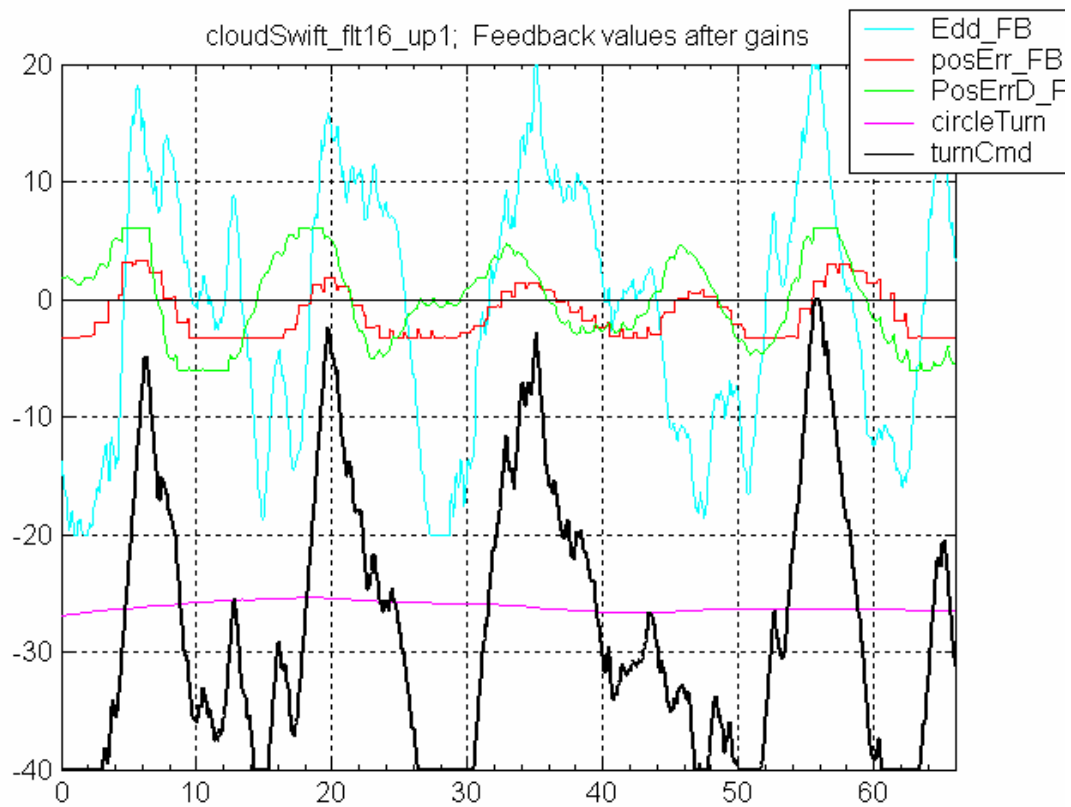
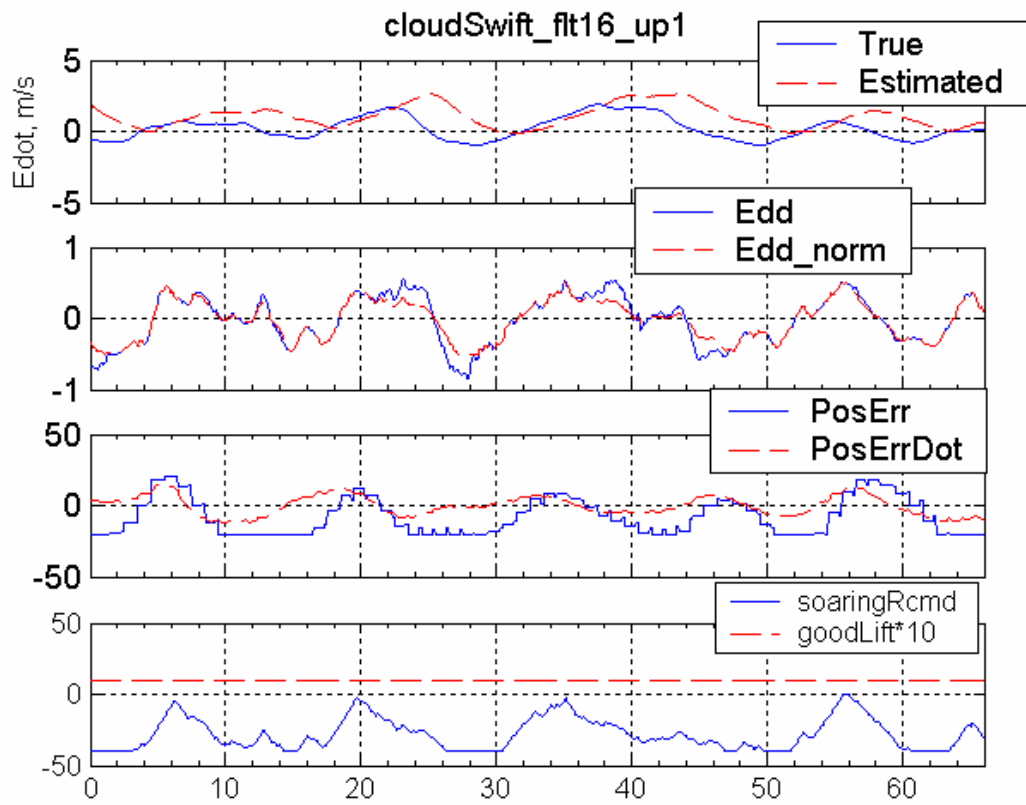




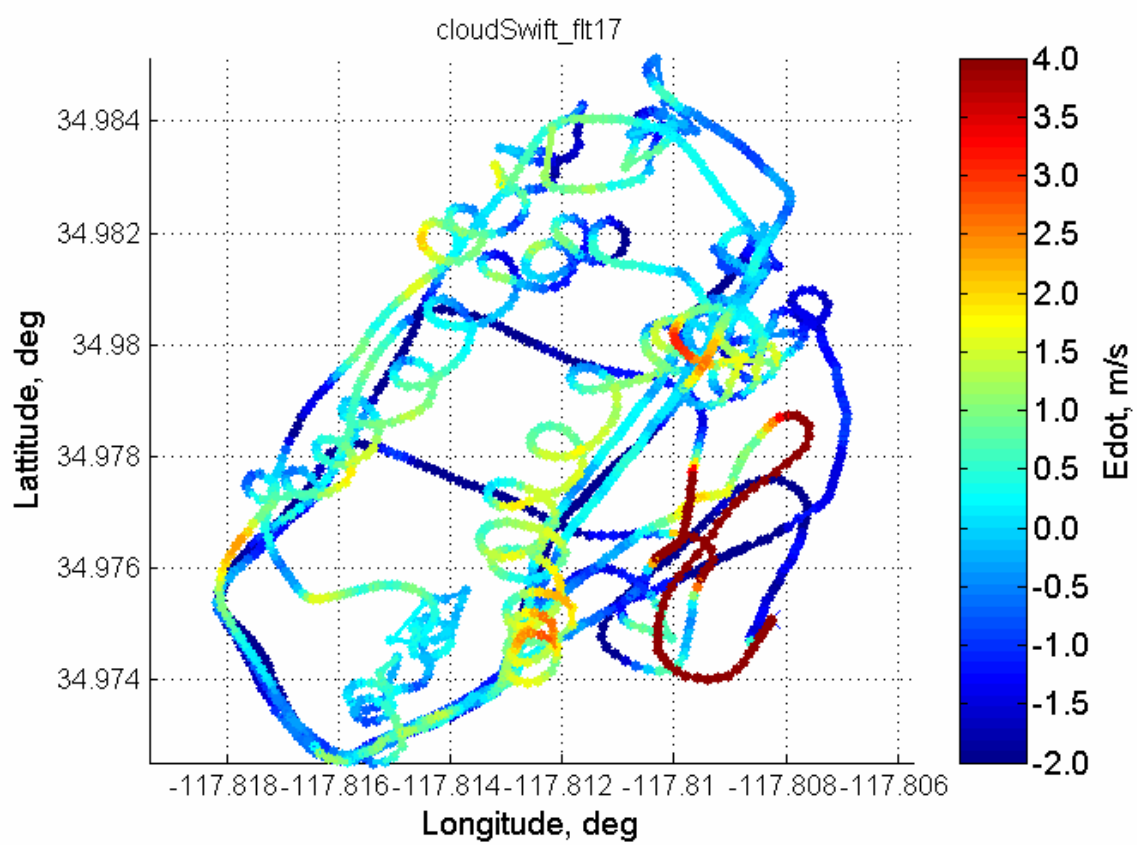
Flight 16, updraft 1b

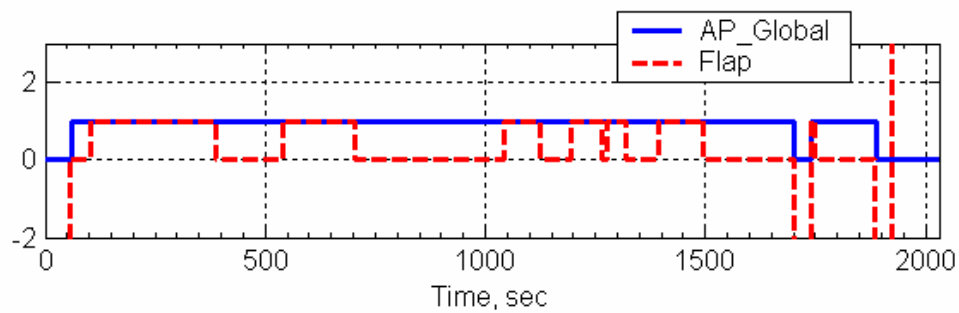
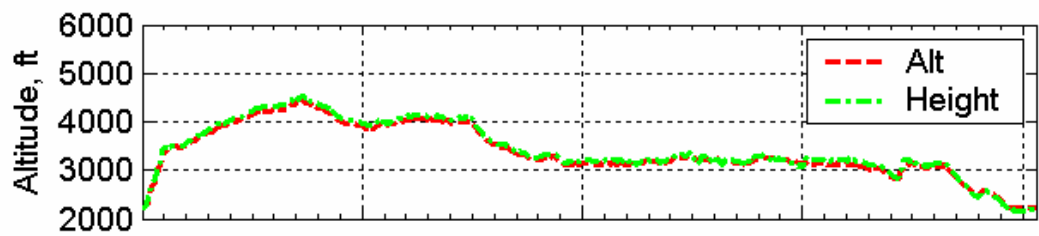
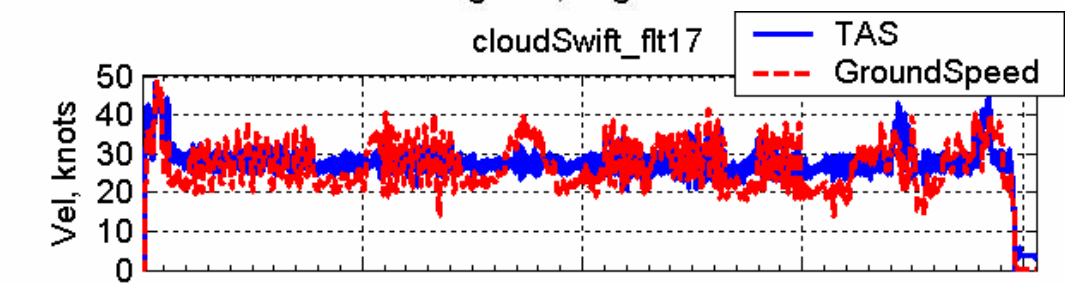
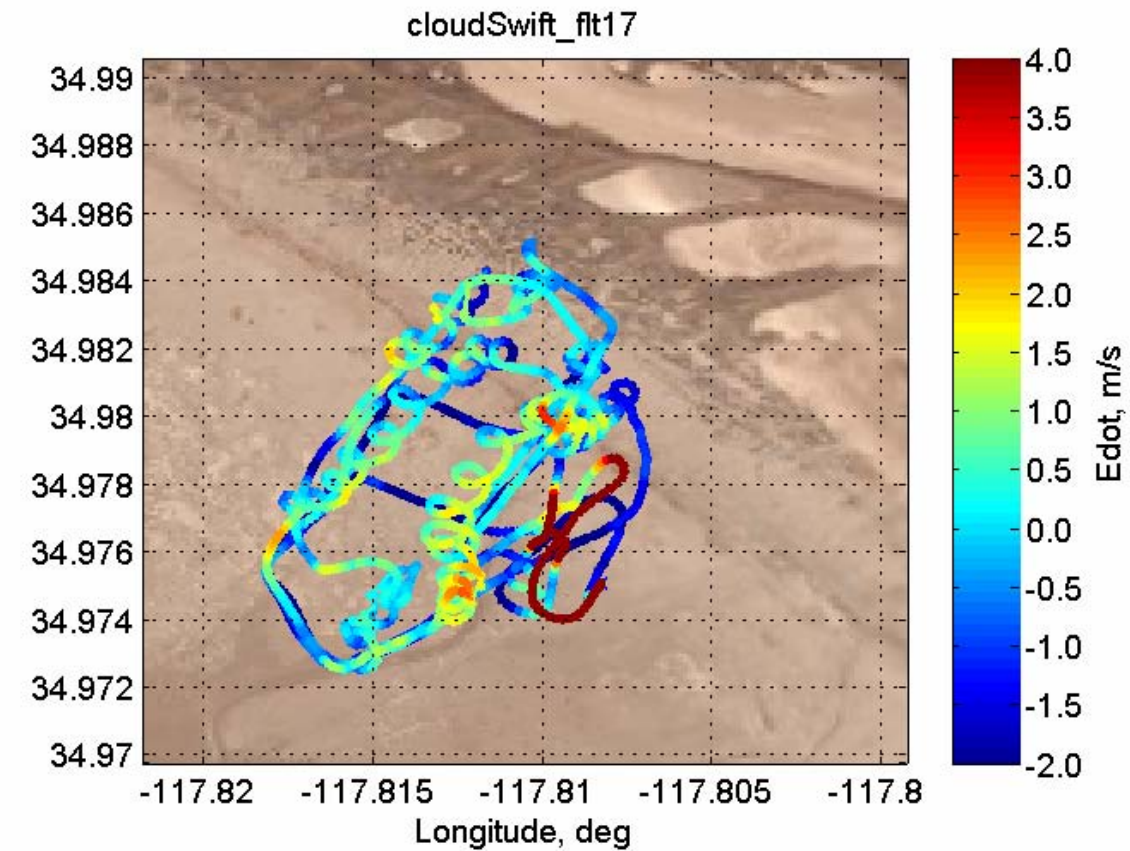
This is a closer look at a section of updraft 1.

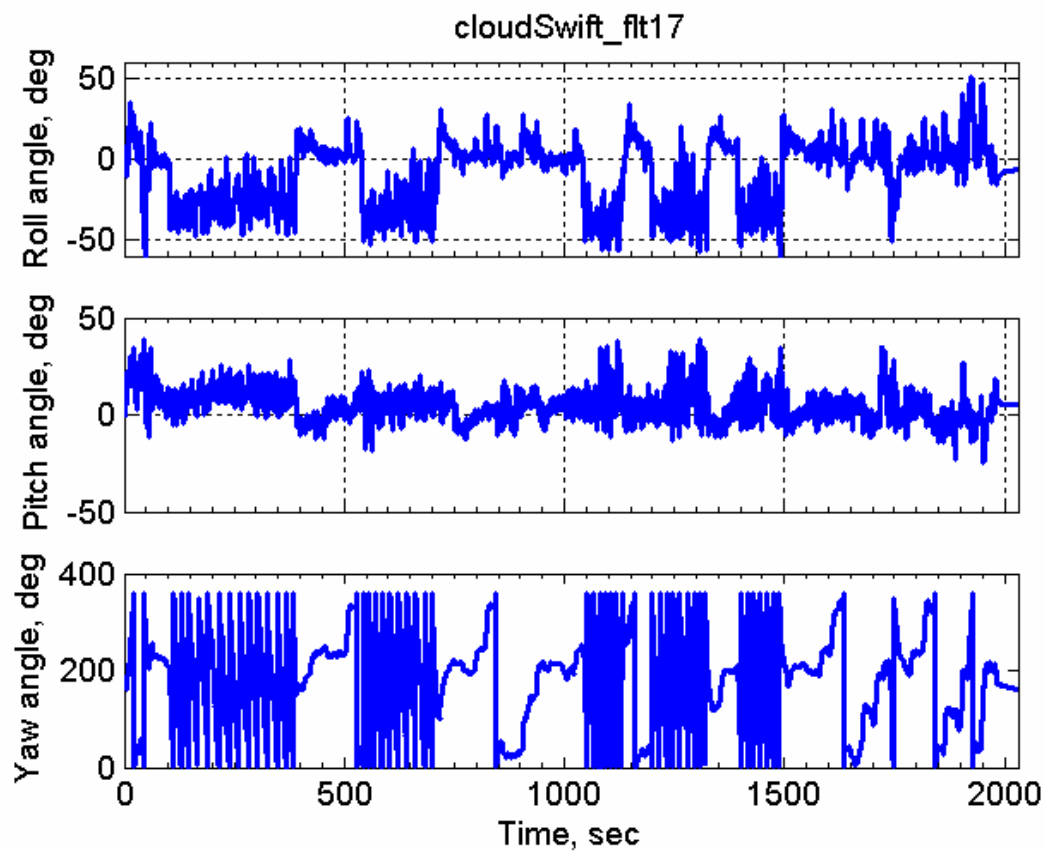
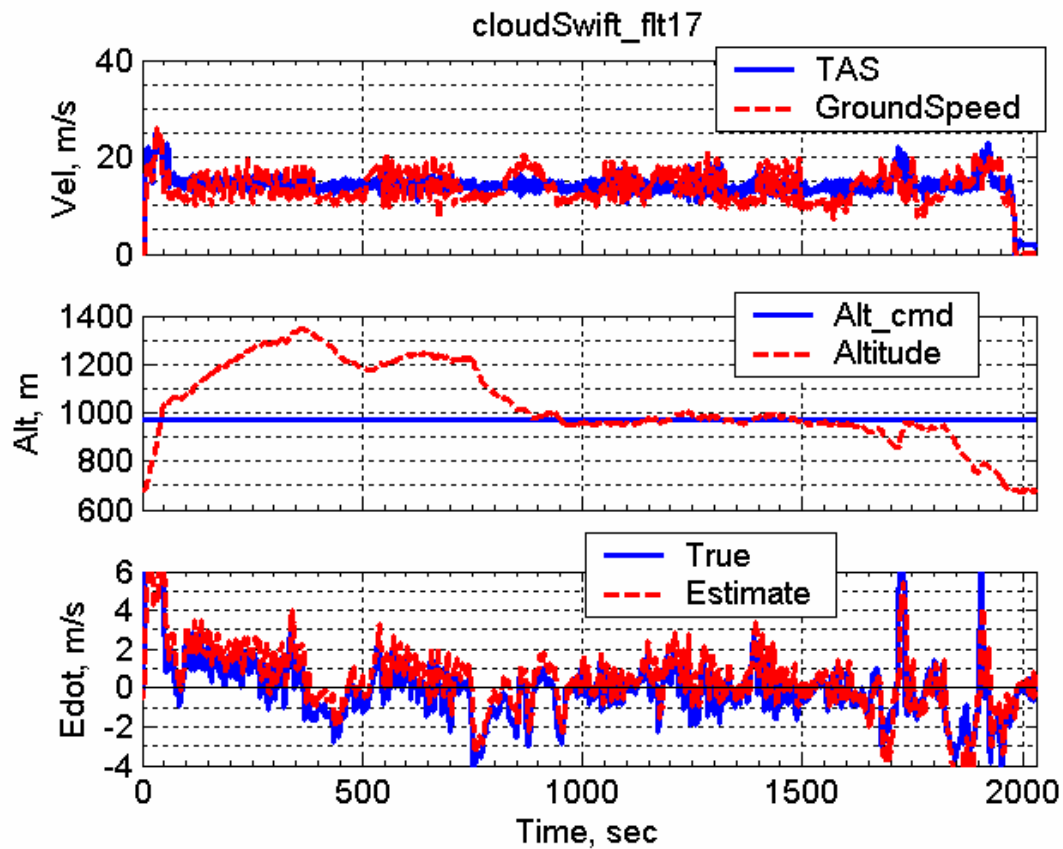


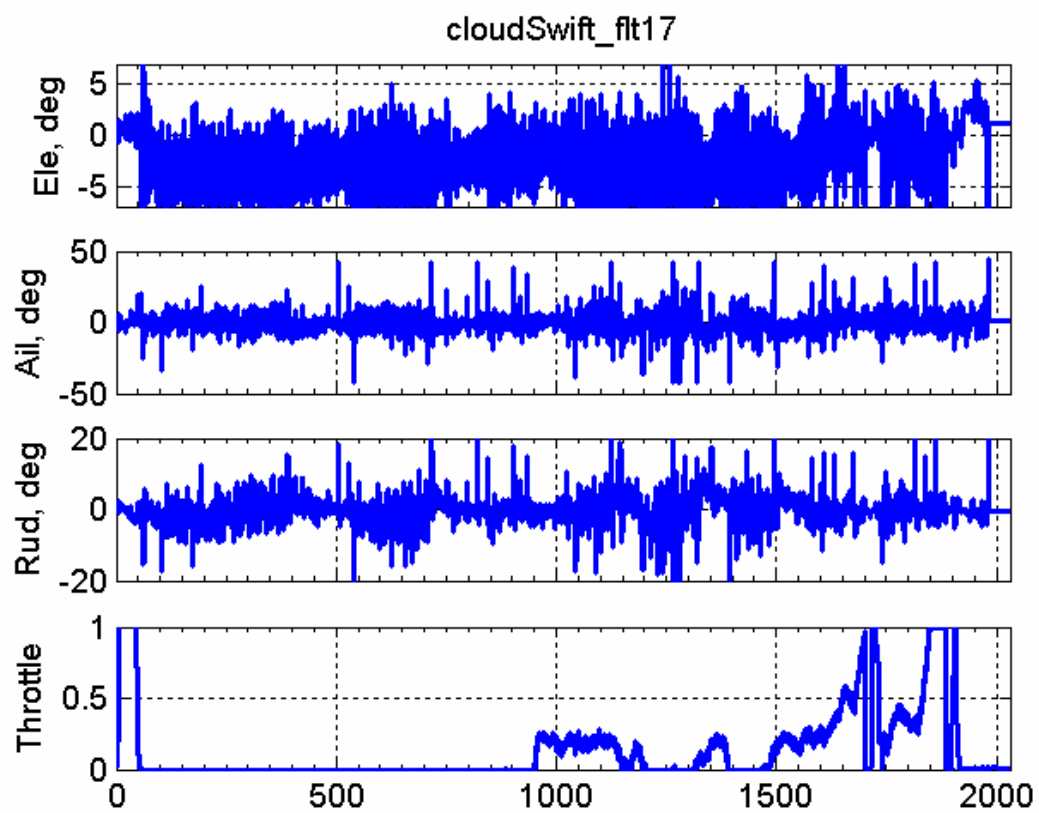


Flight 17



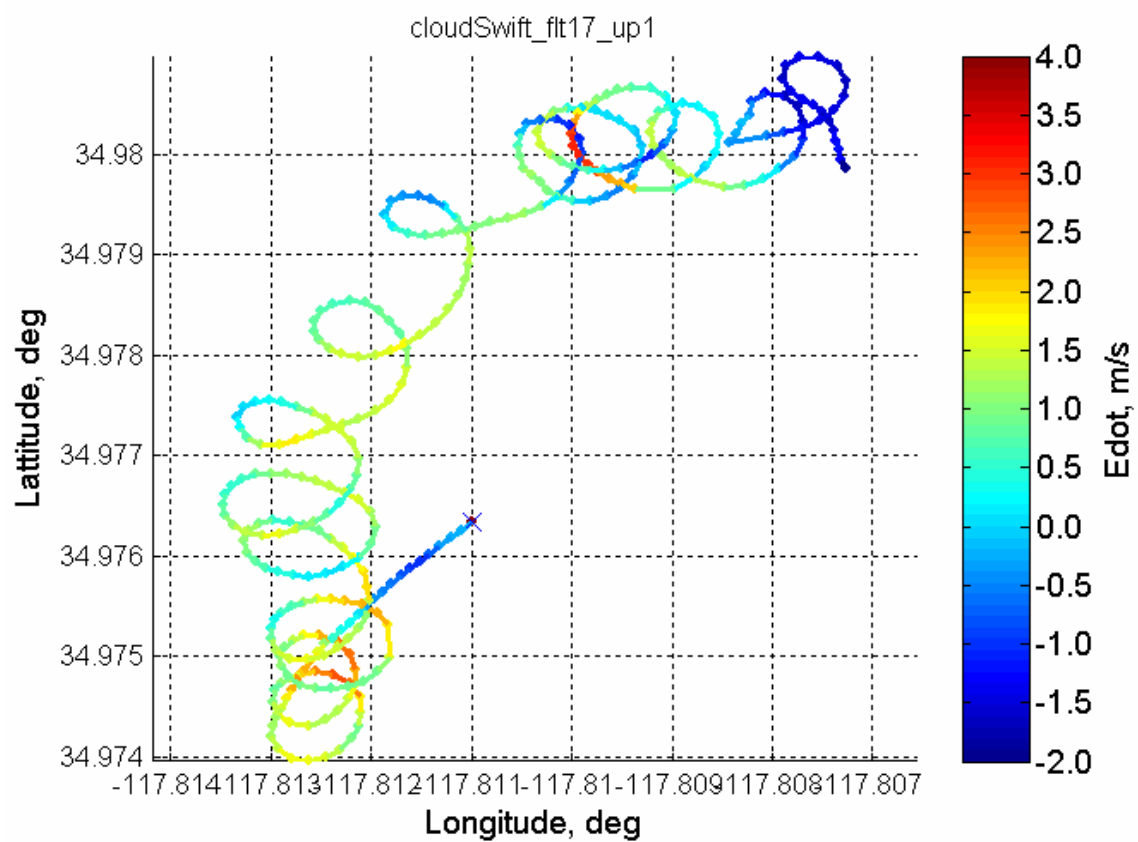


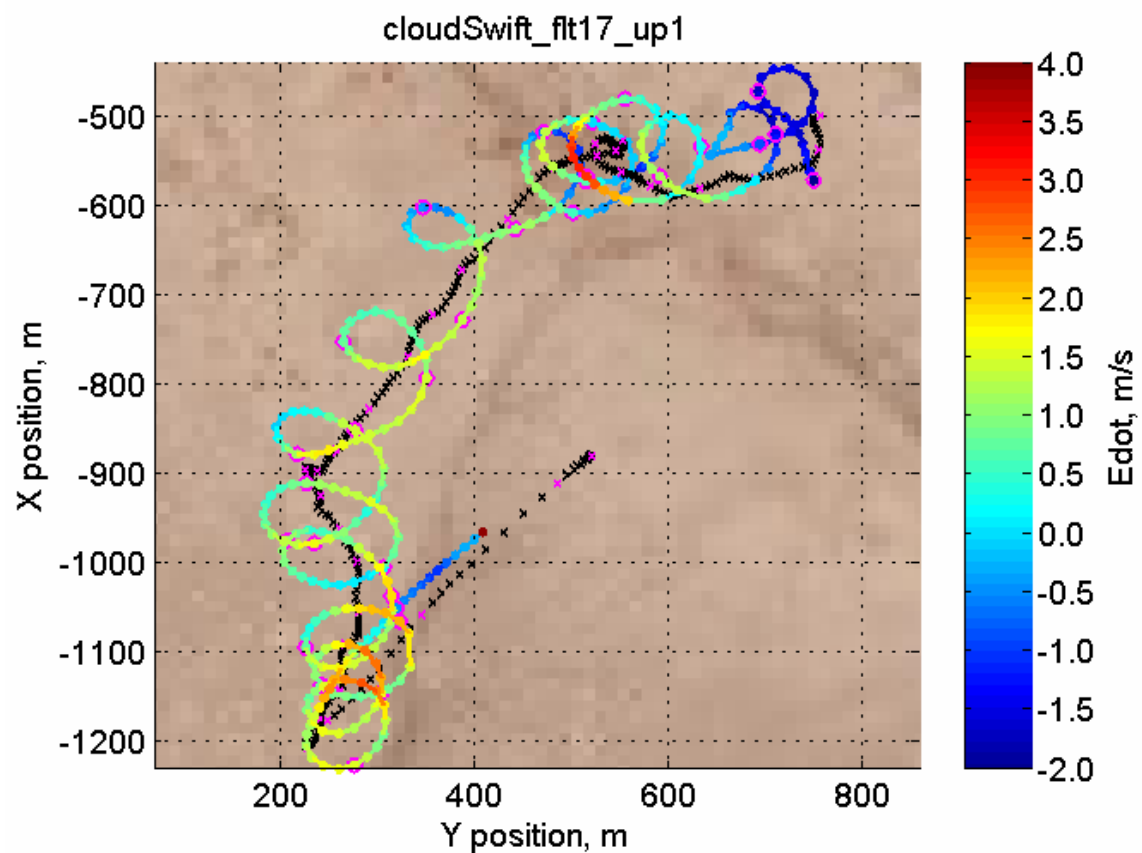
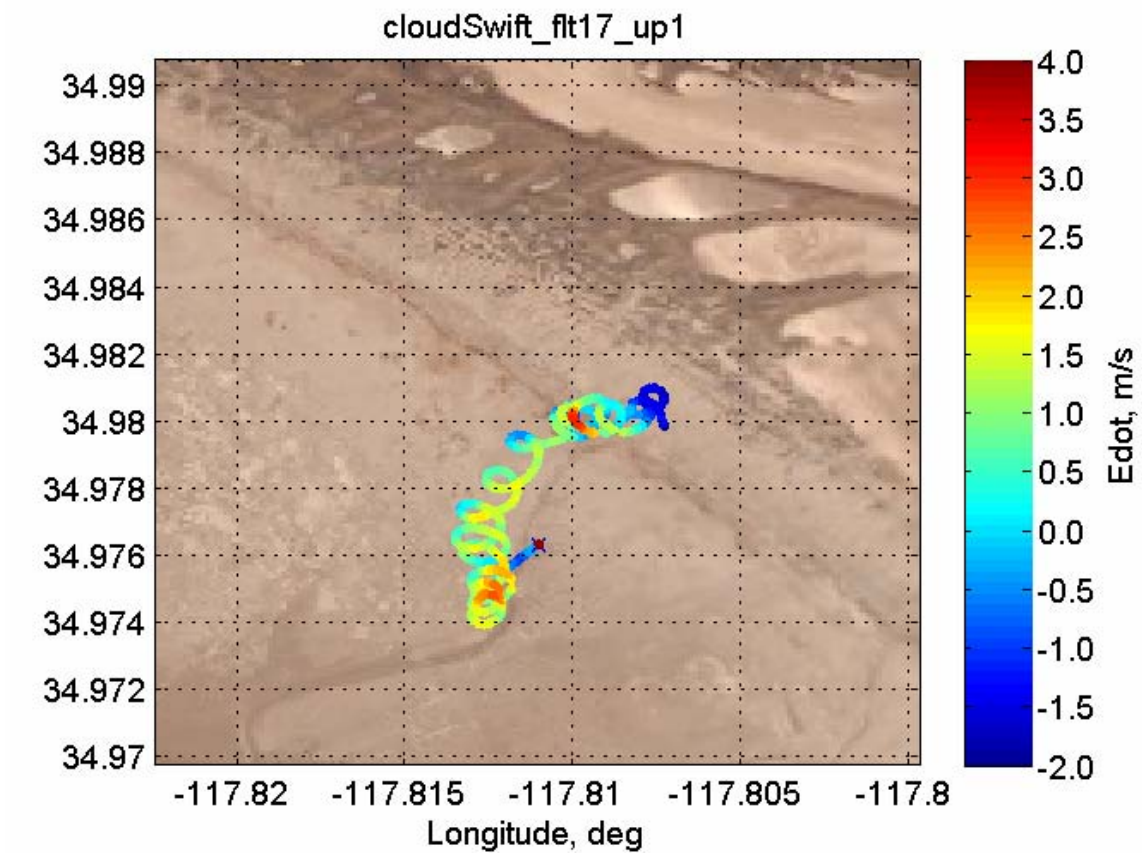


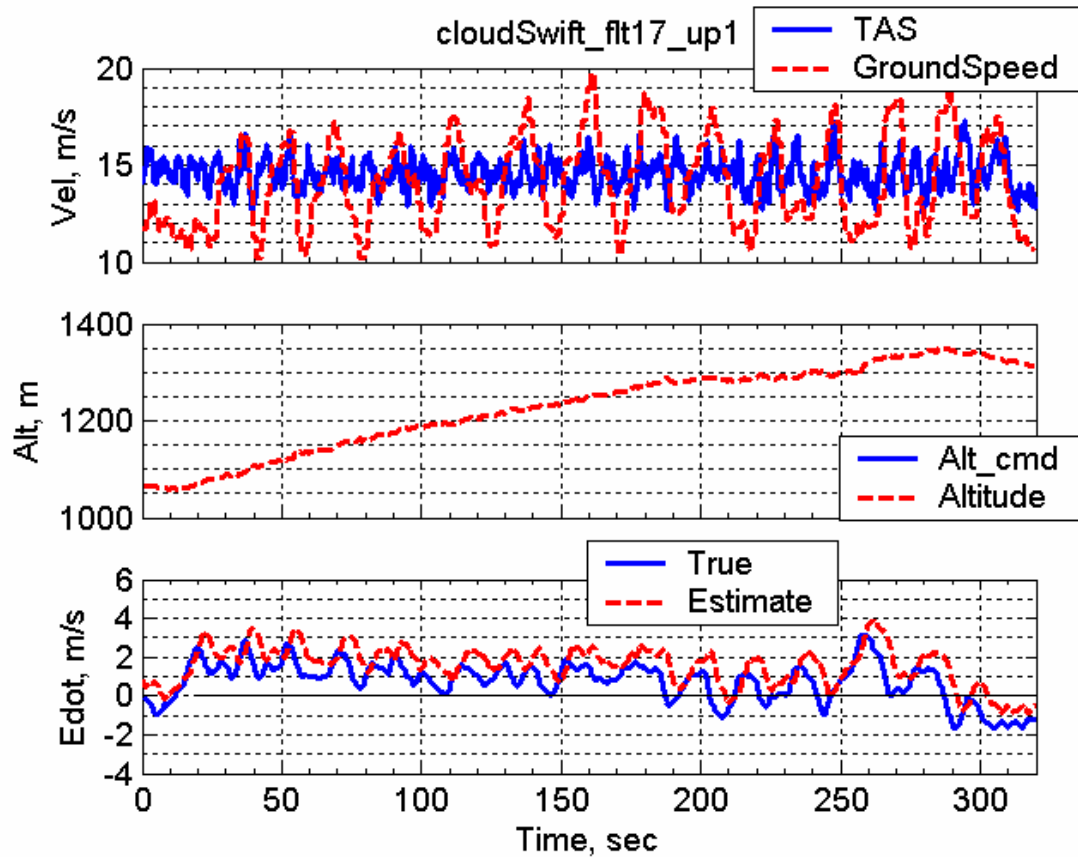
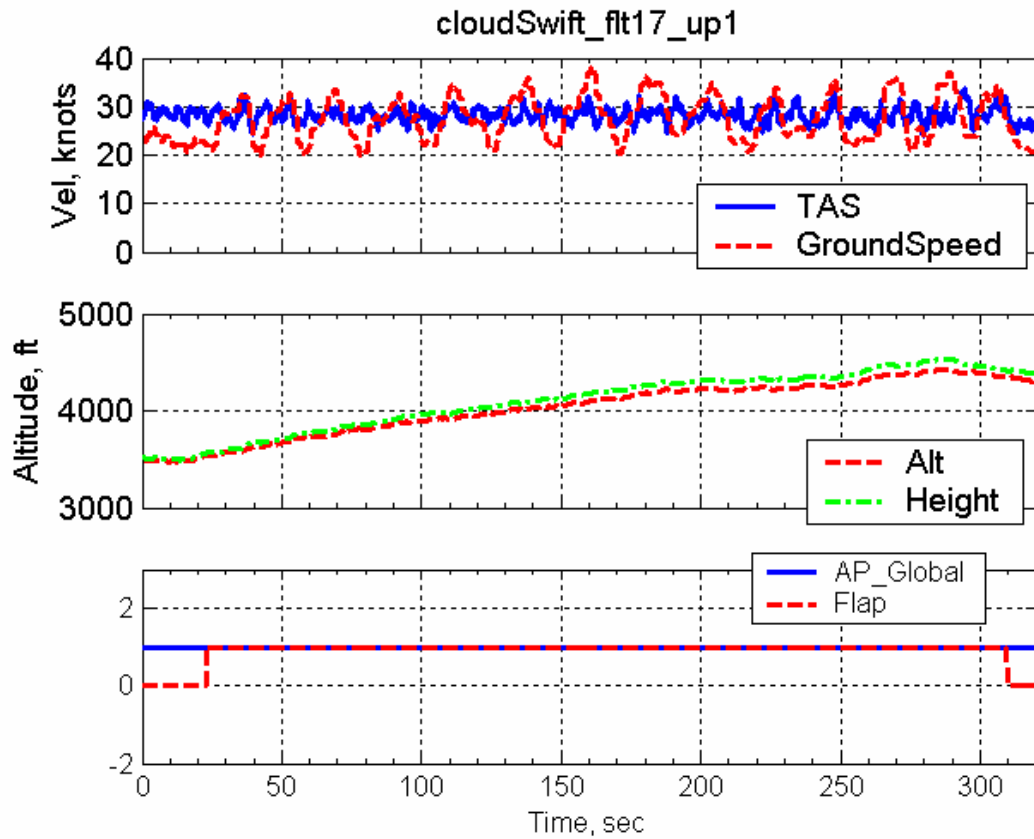


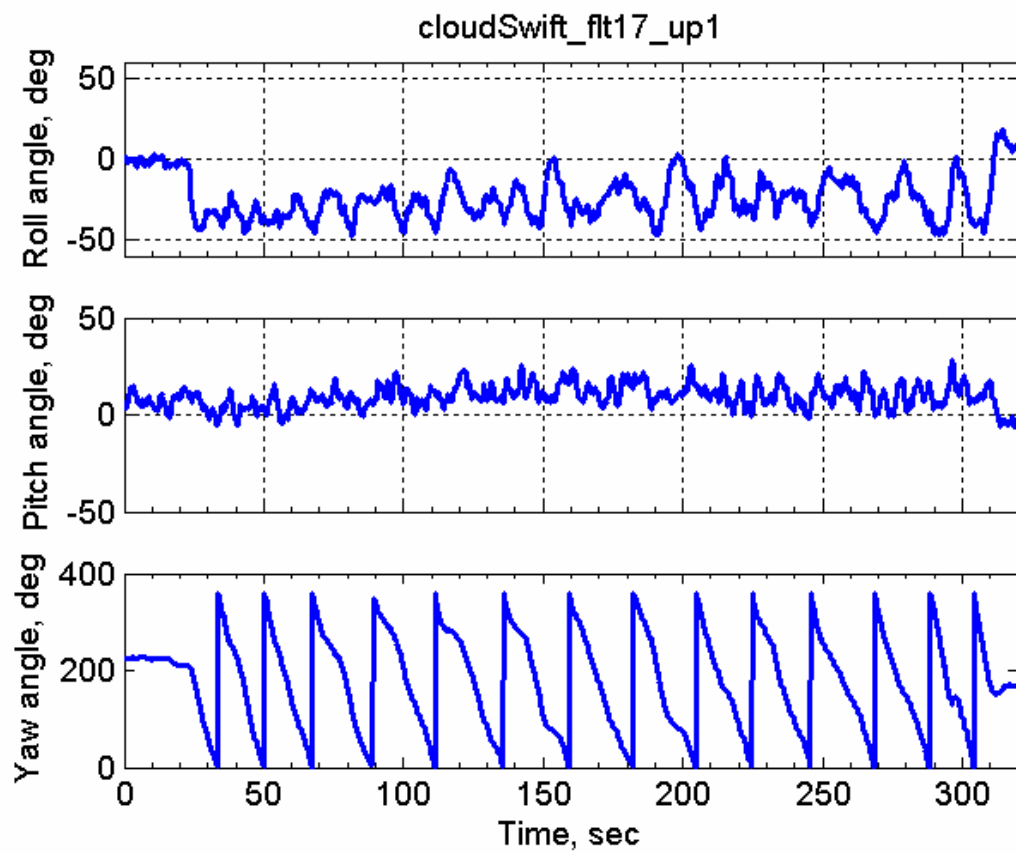
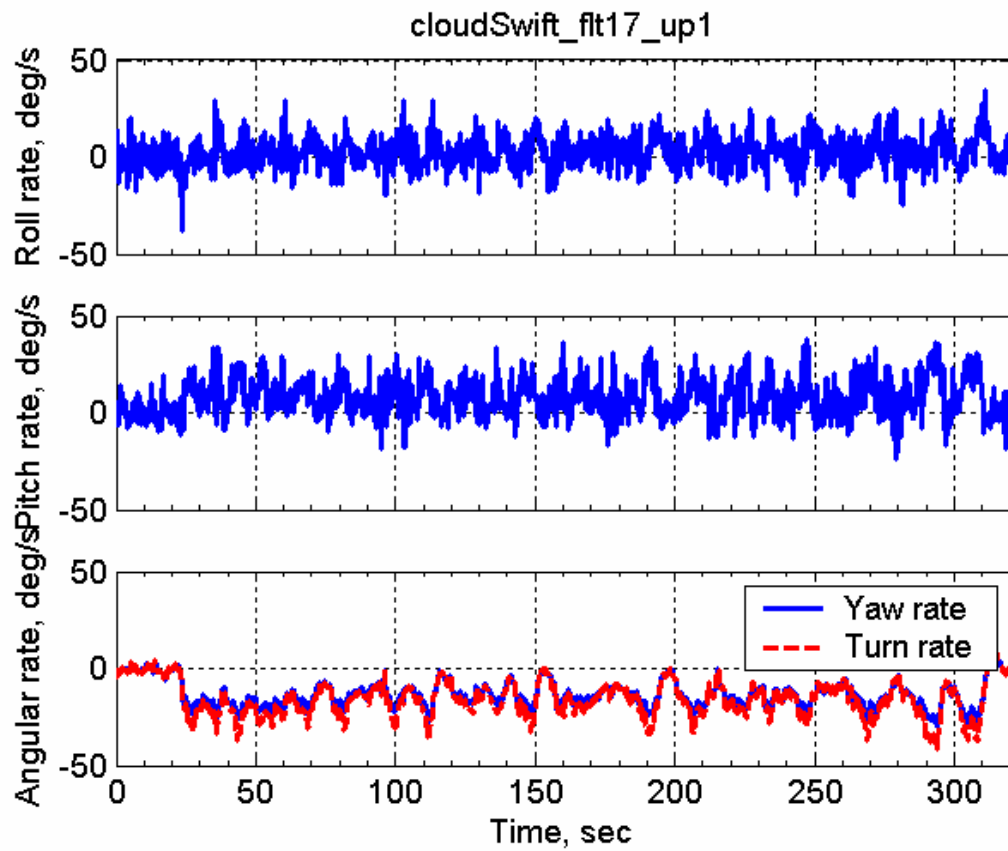
Flight 17, updraft 1

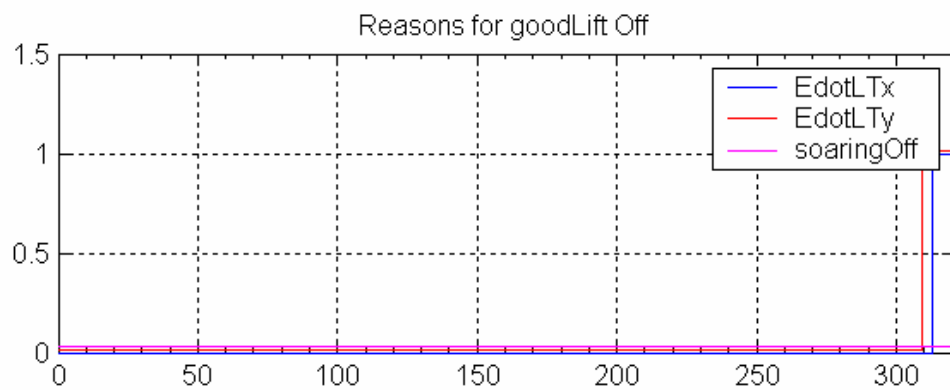
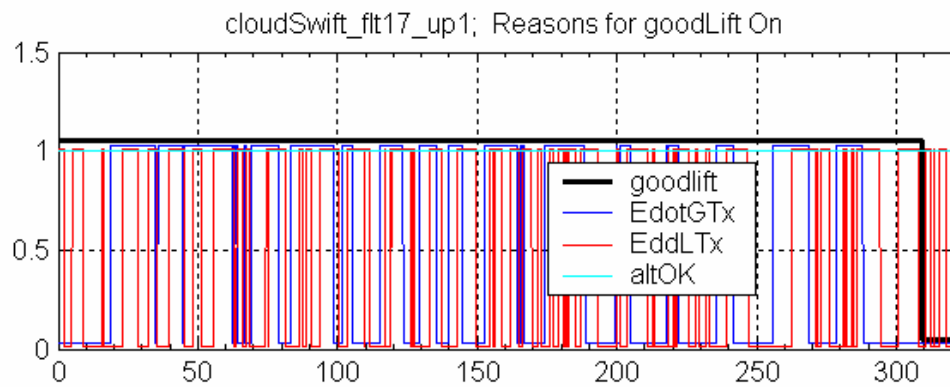
Good centering in weak and changing lift with wind. Why did the lift suddenly get stronger at $t=260$?

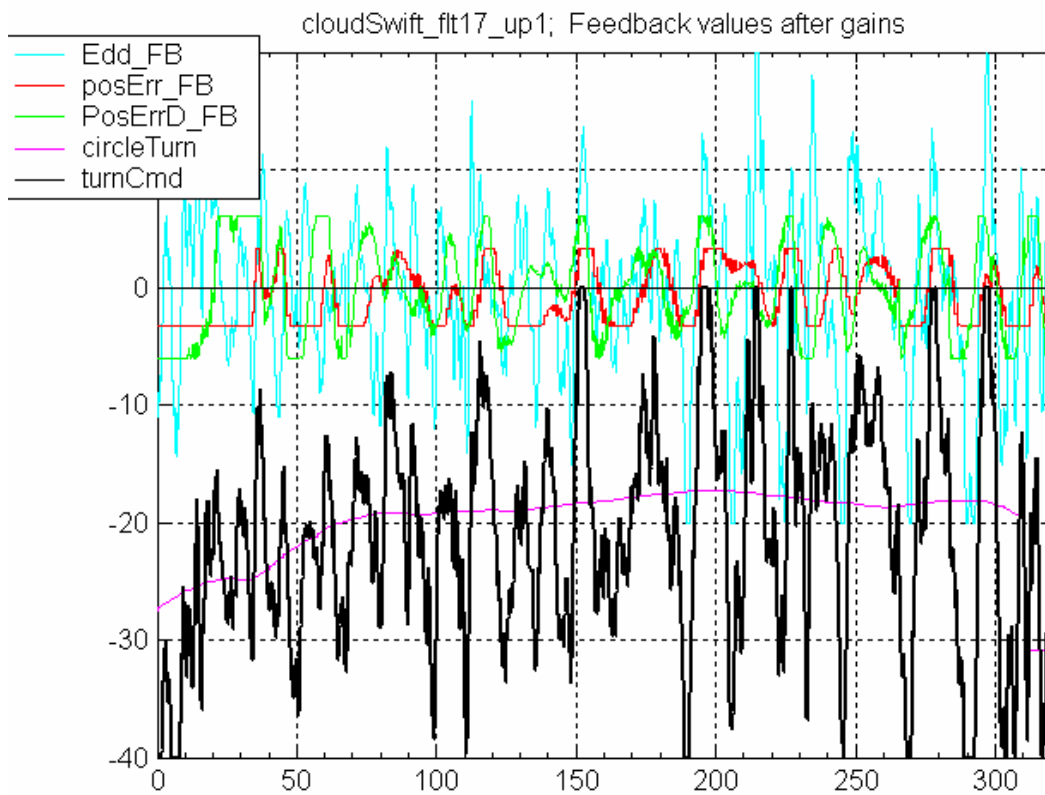
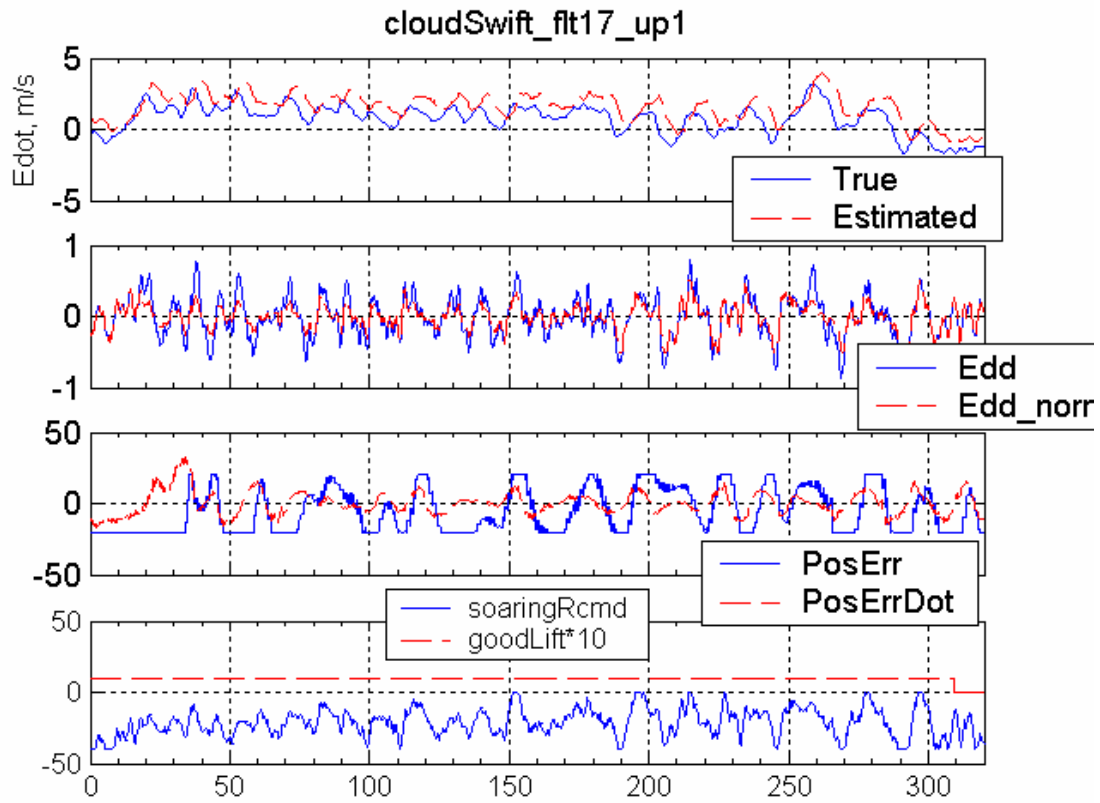




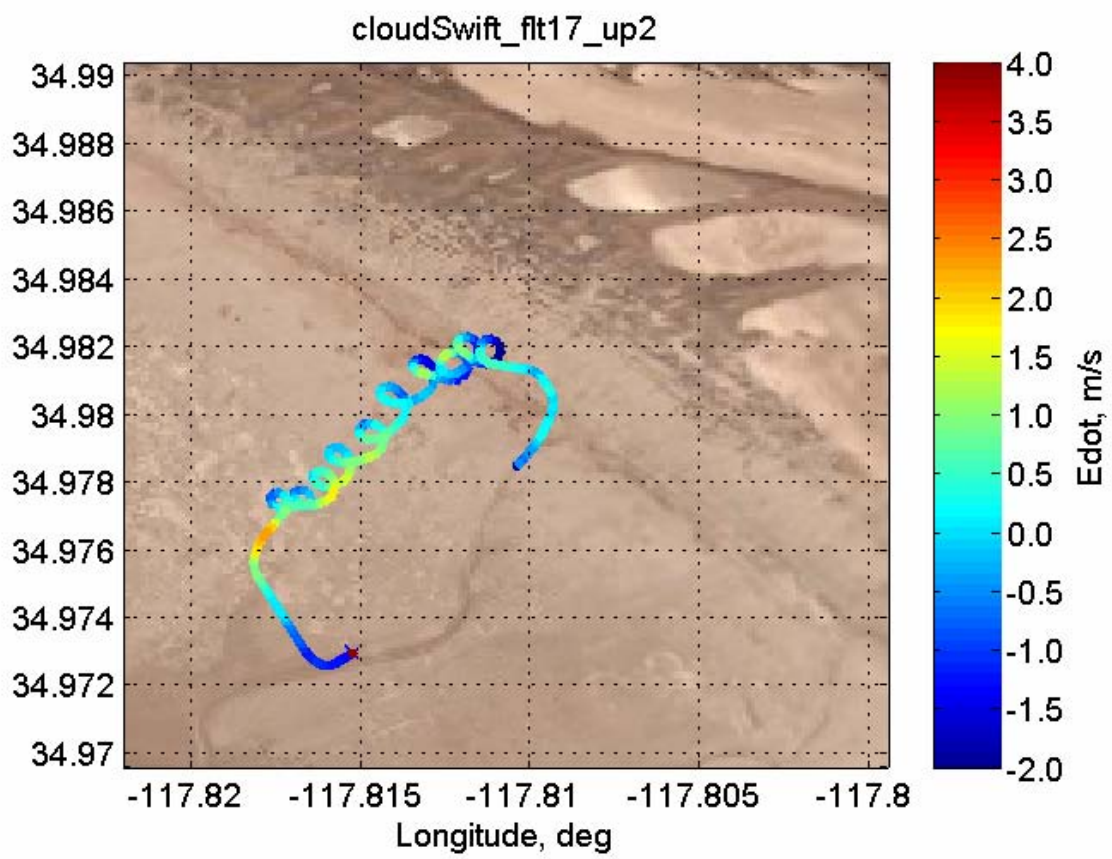


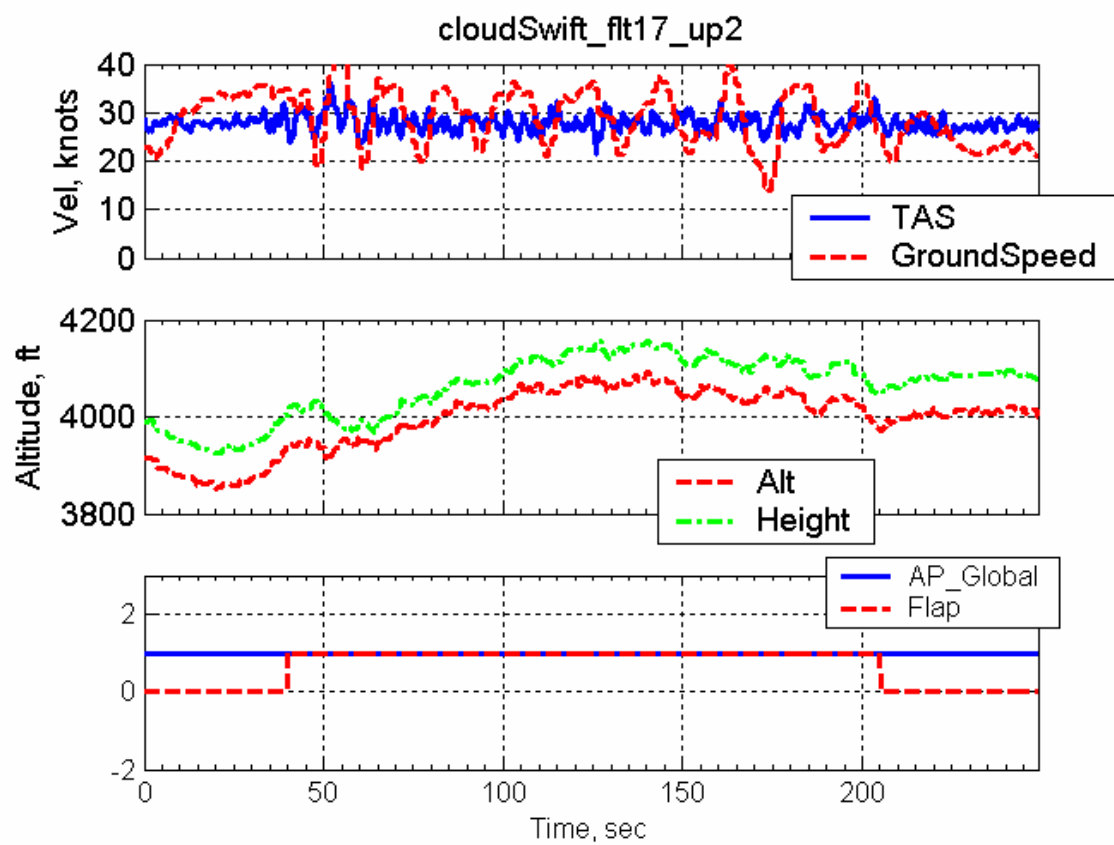
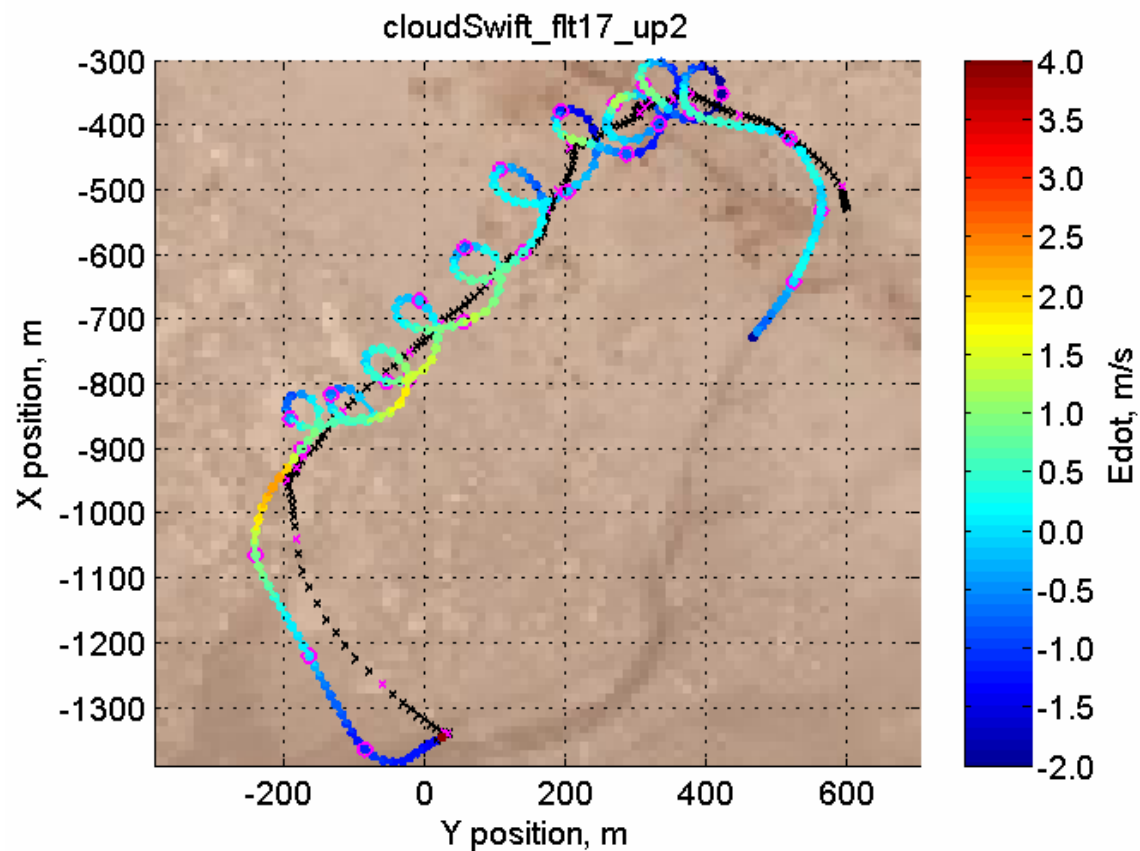


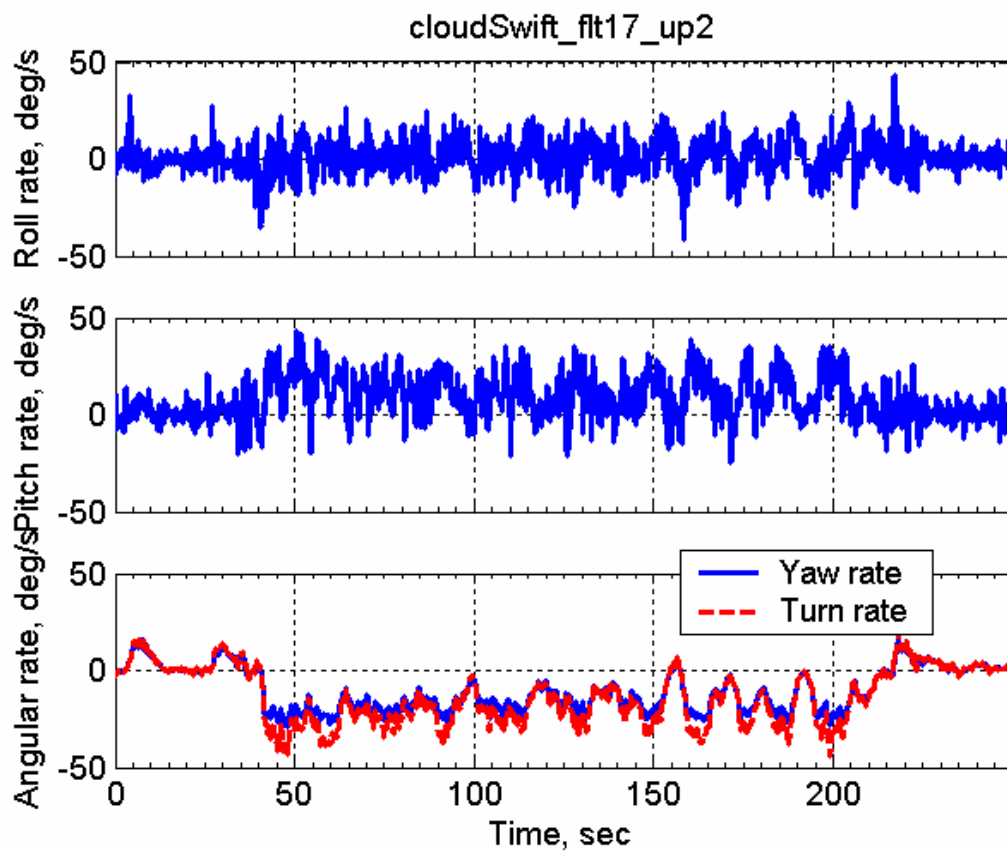
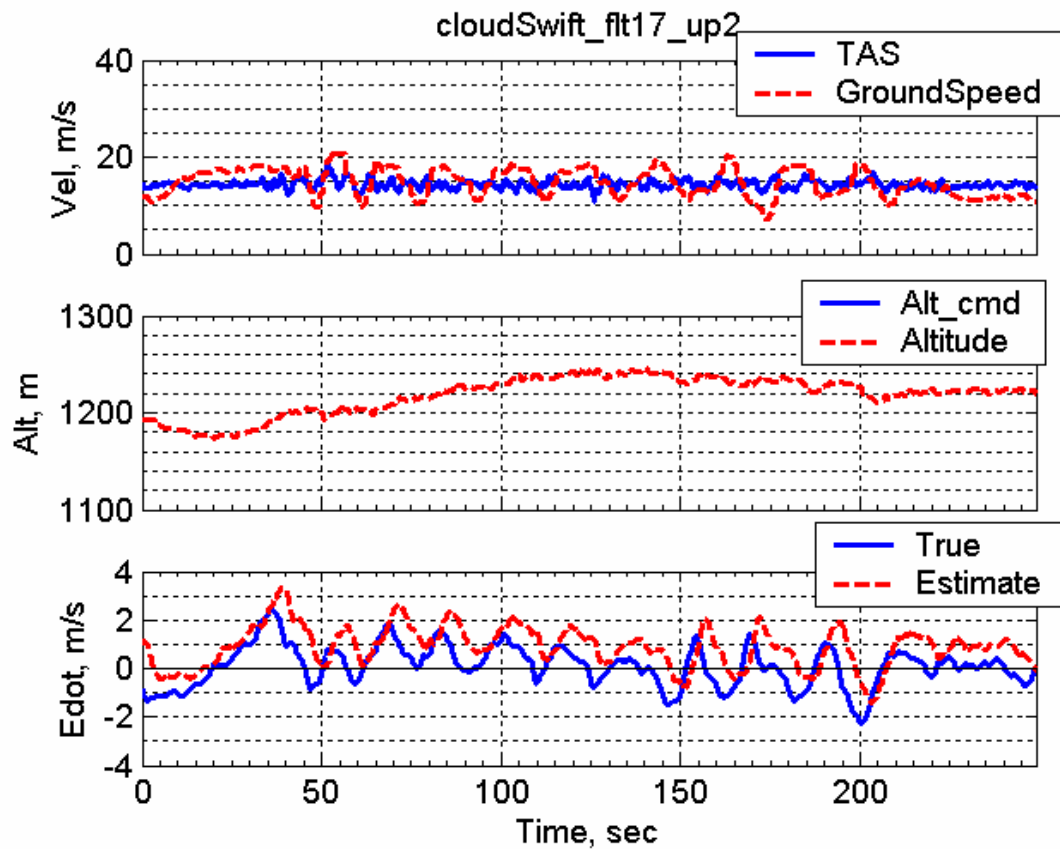


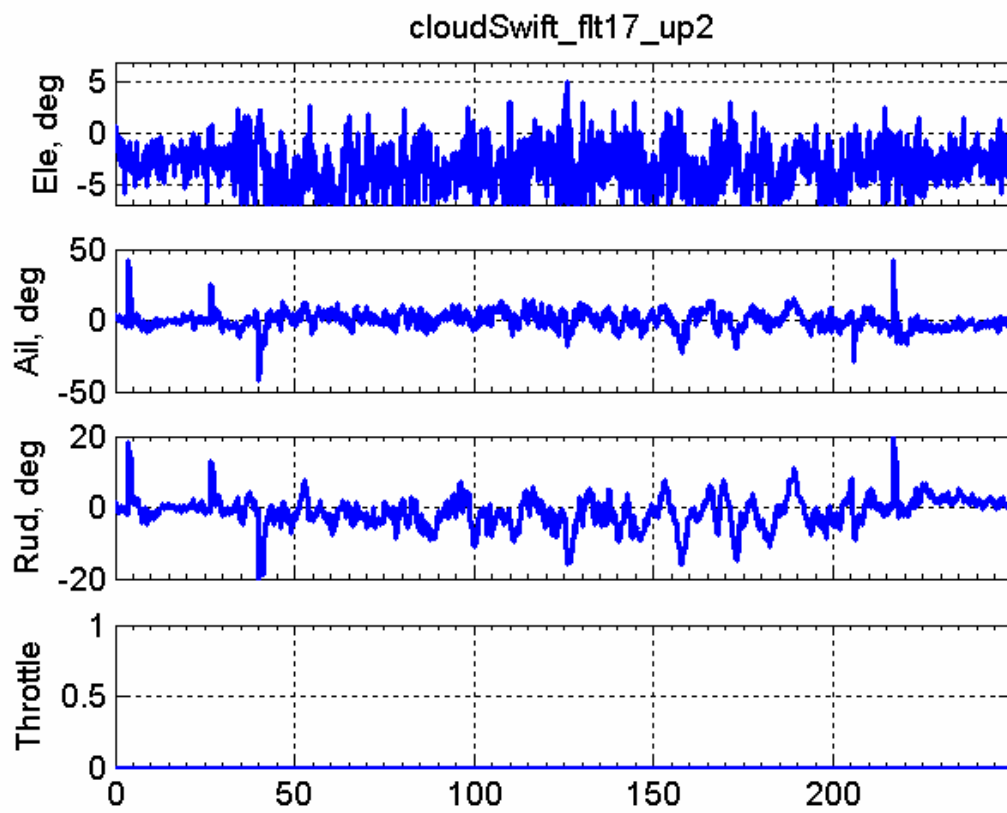
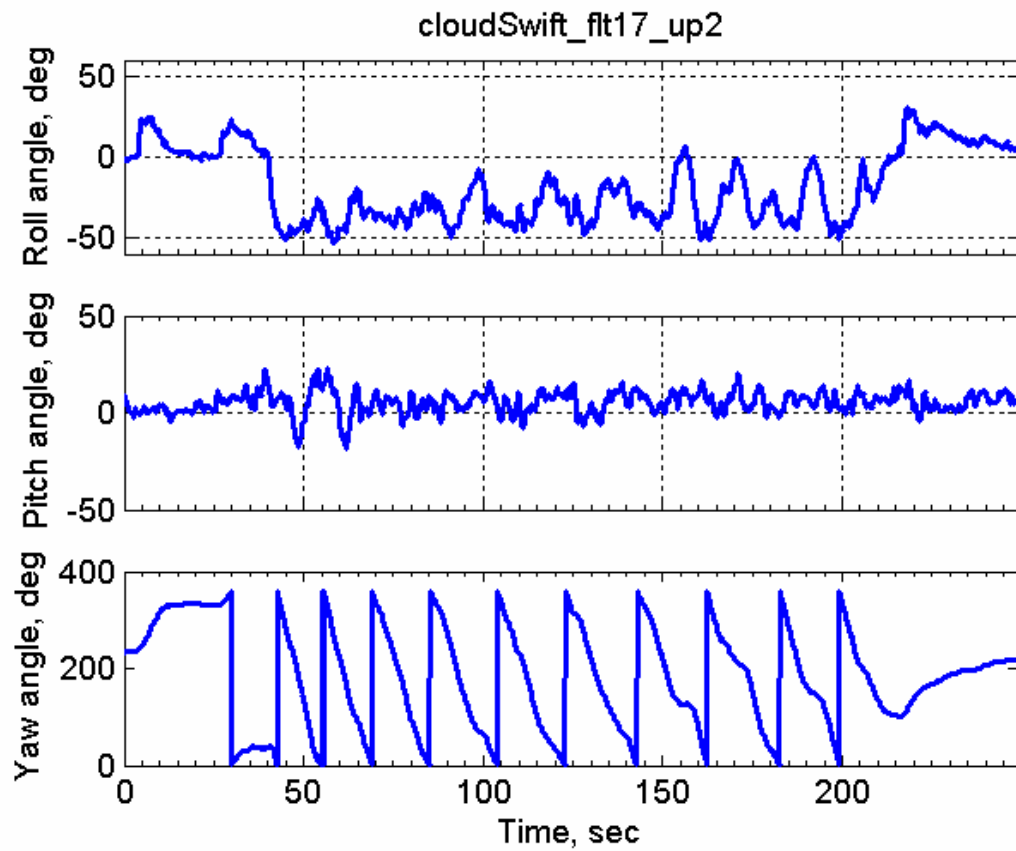


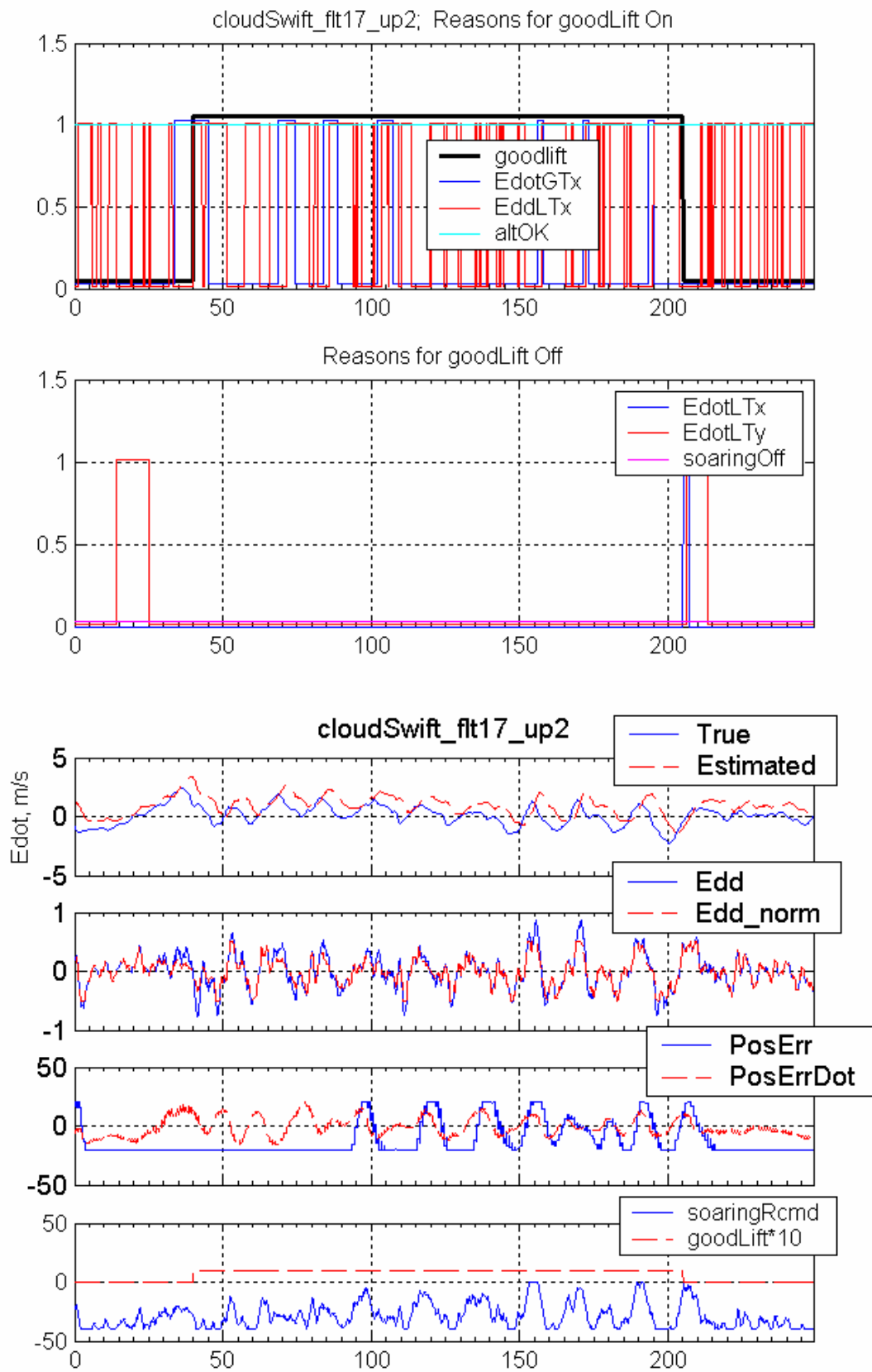
Flight 17, updraft 2

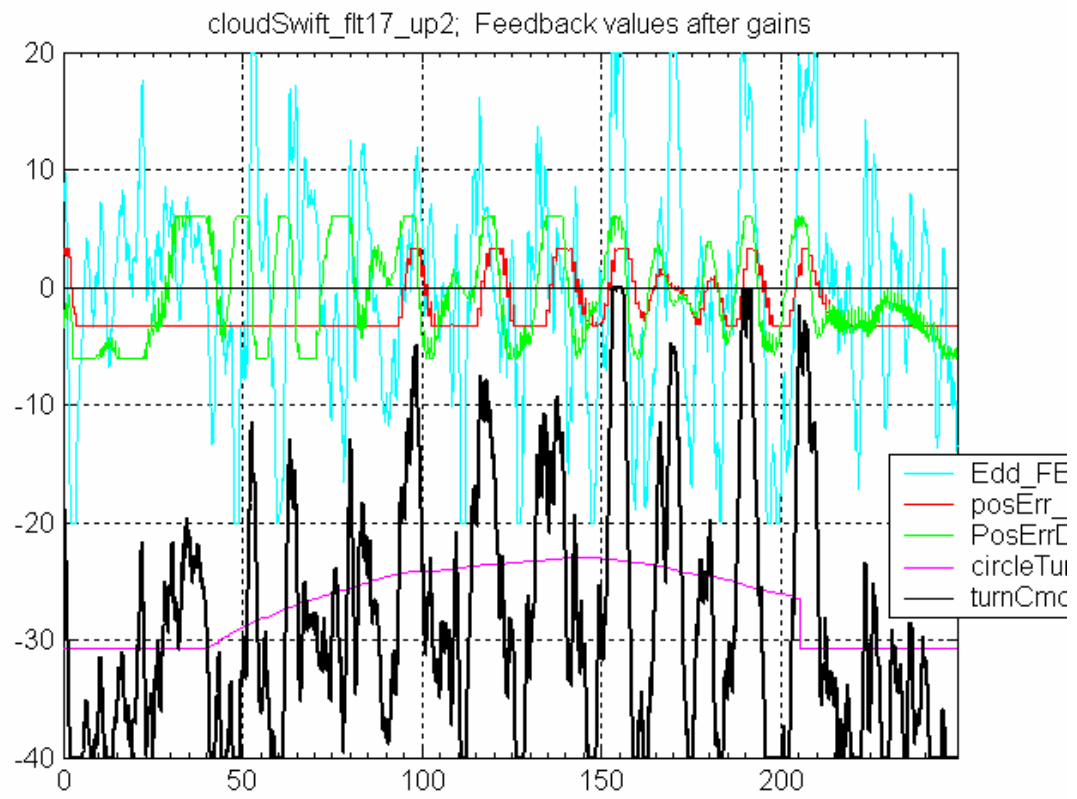






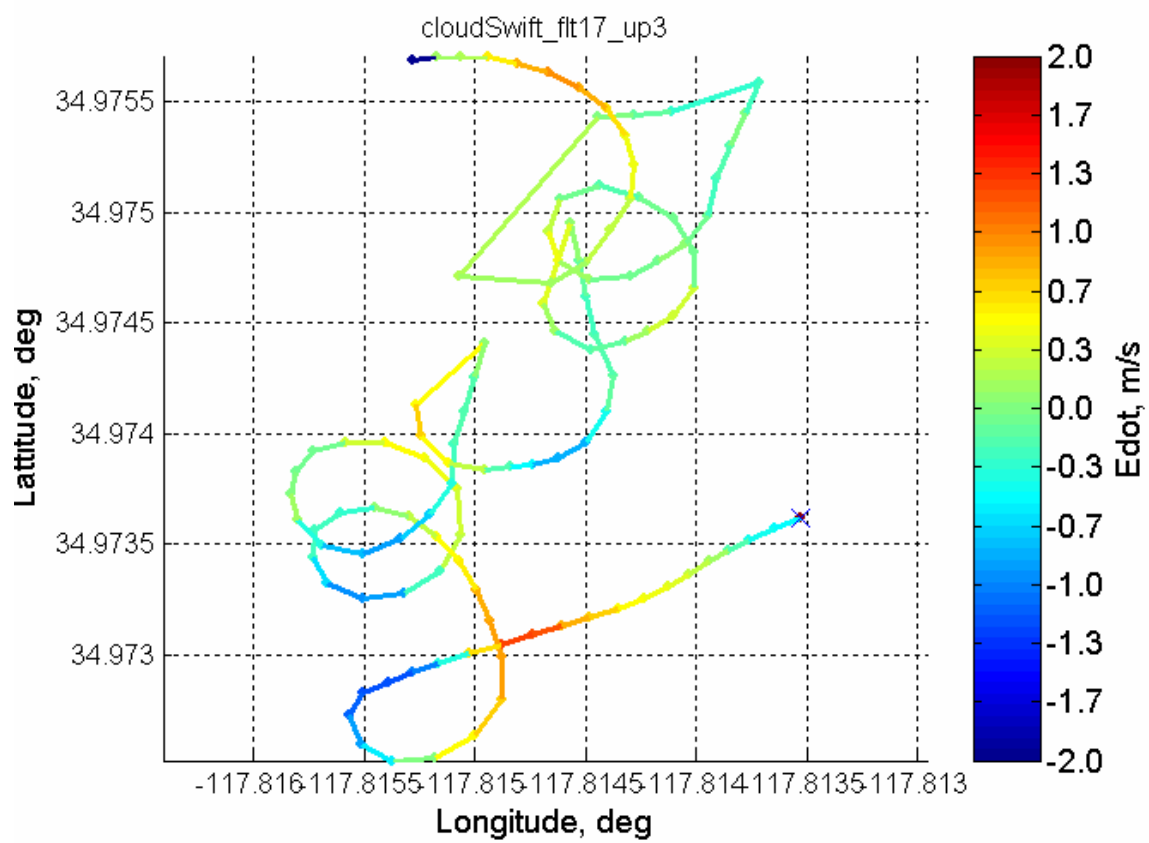


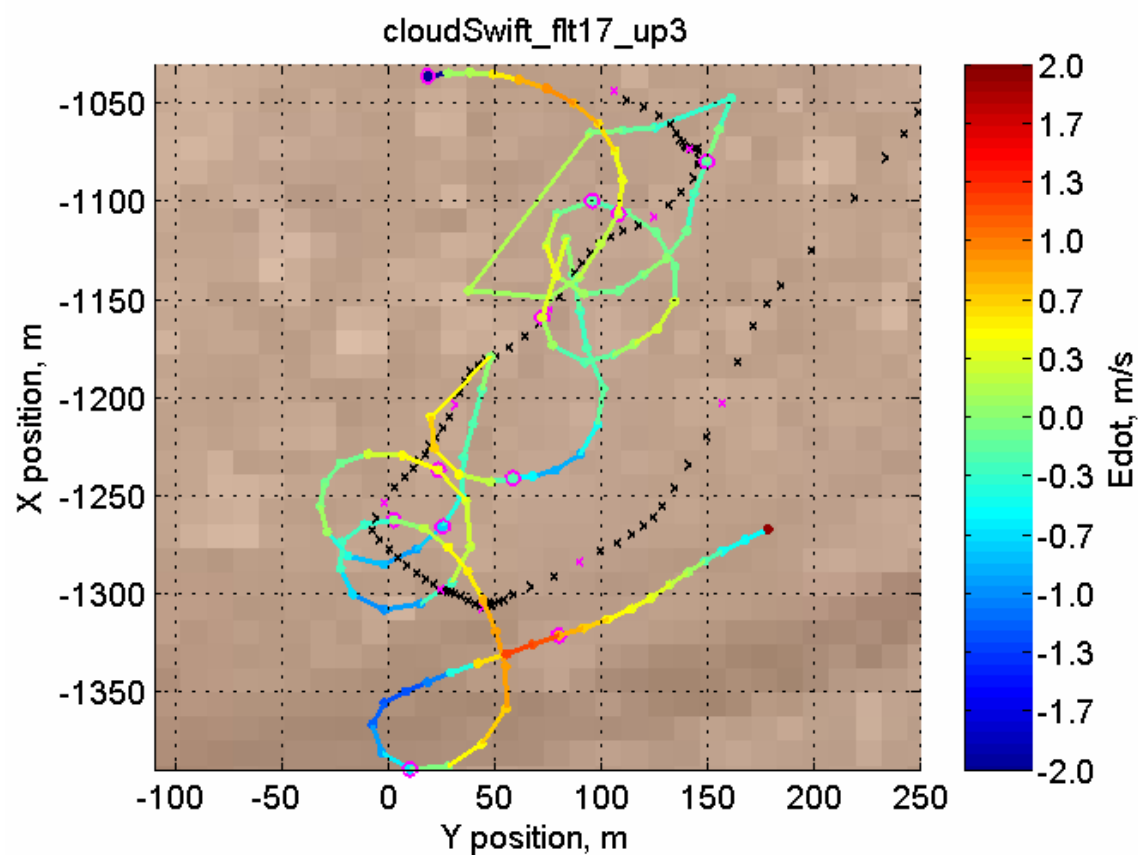
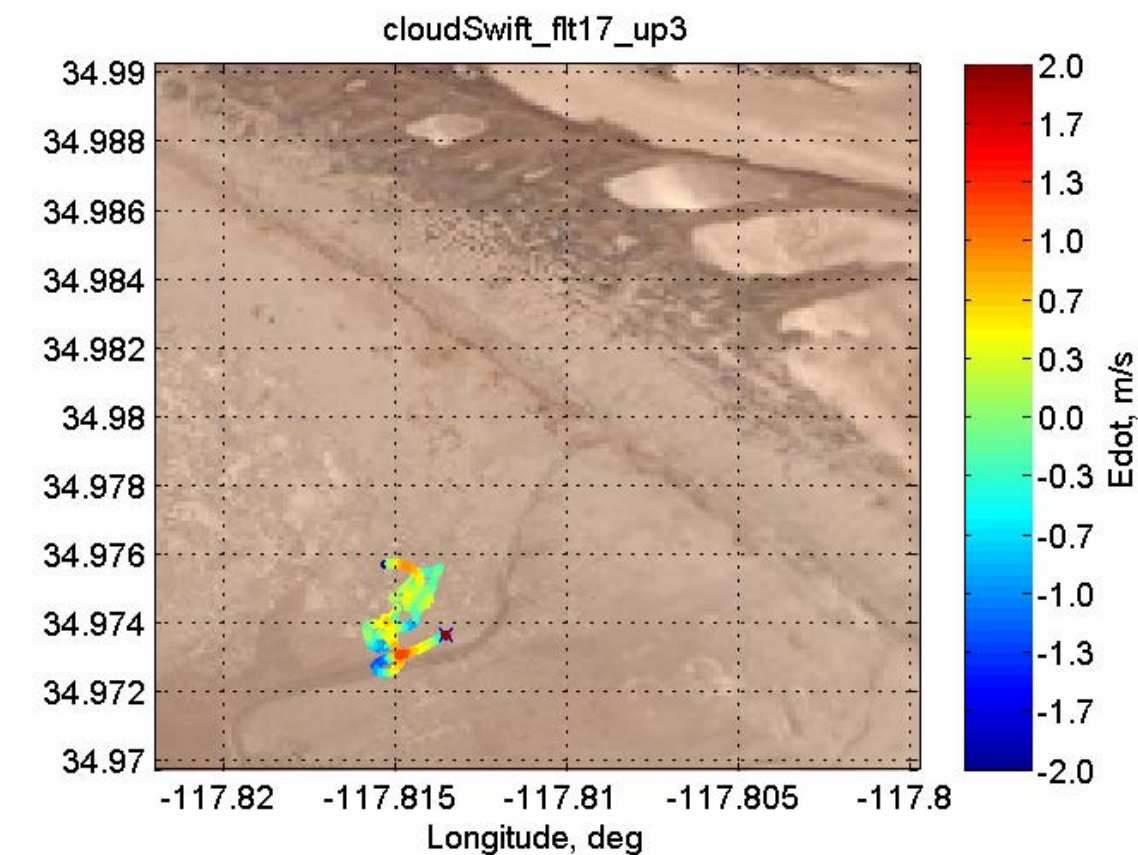


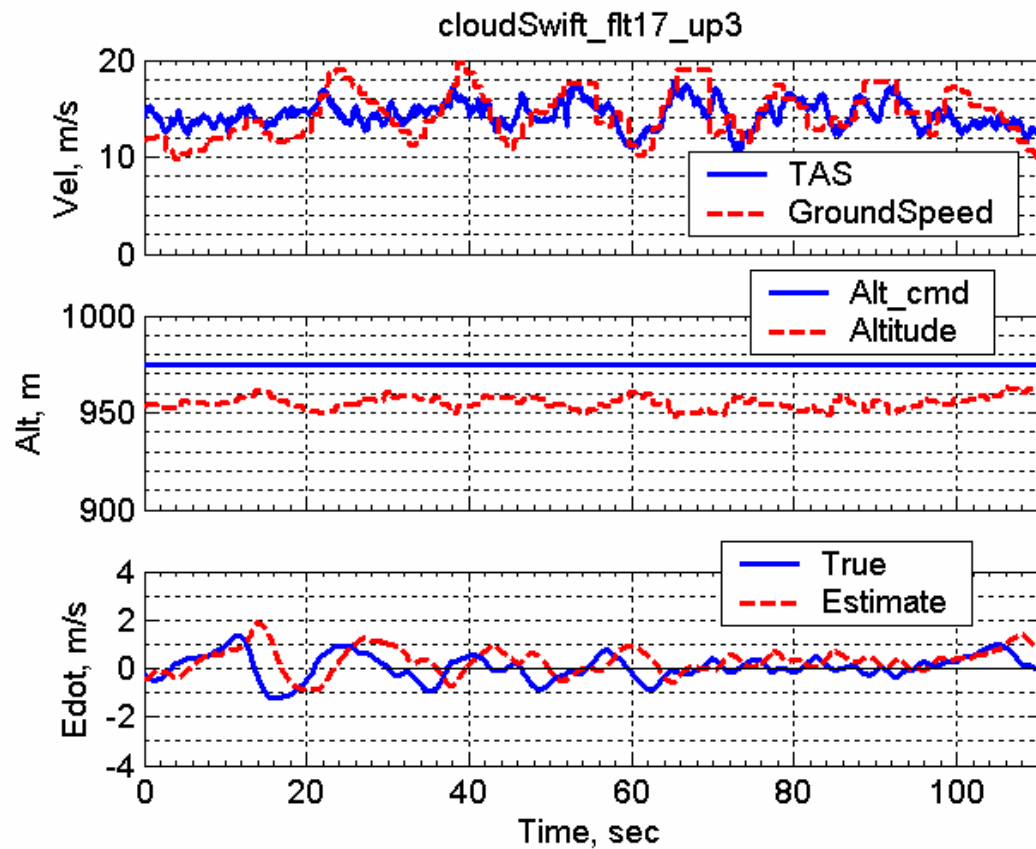
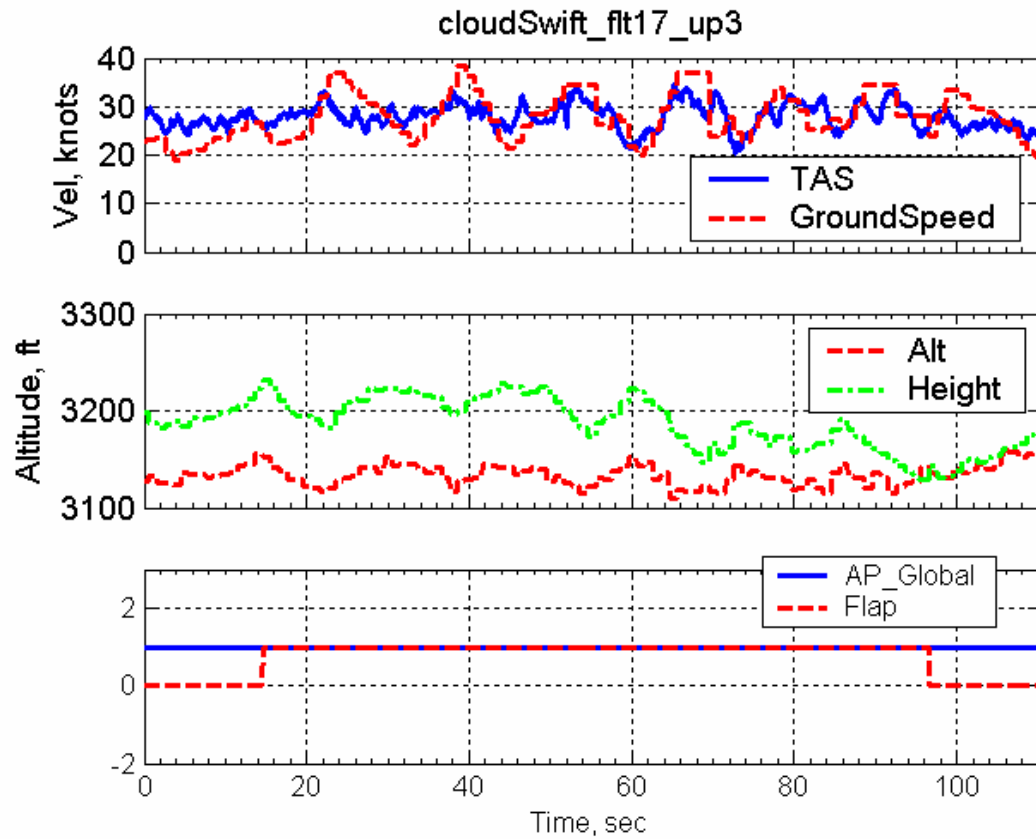


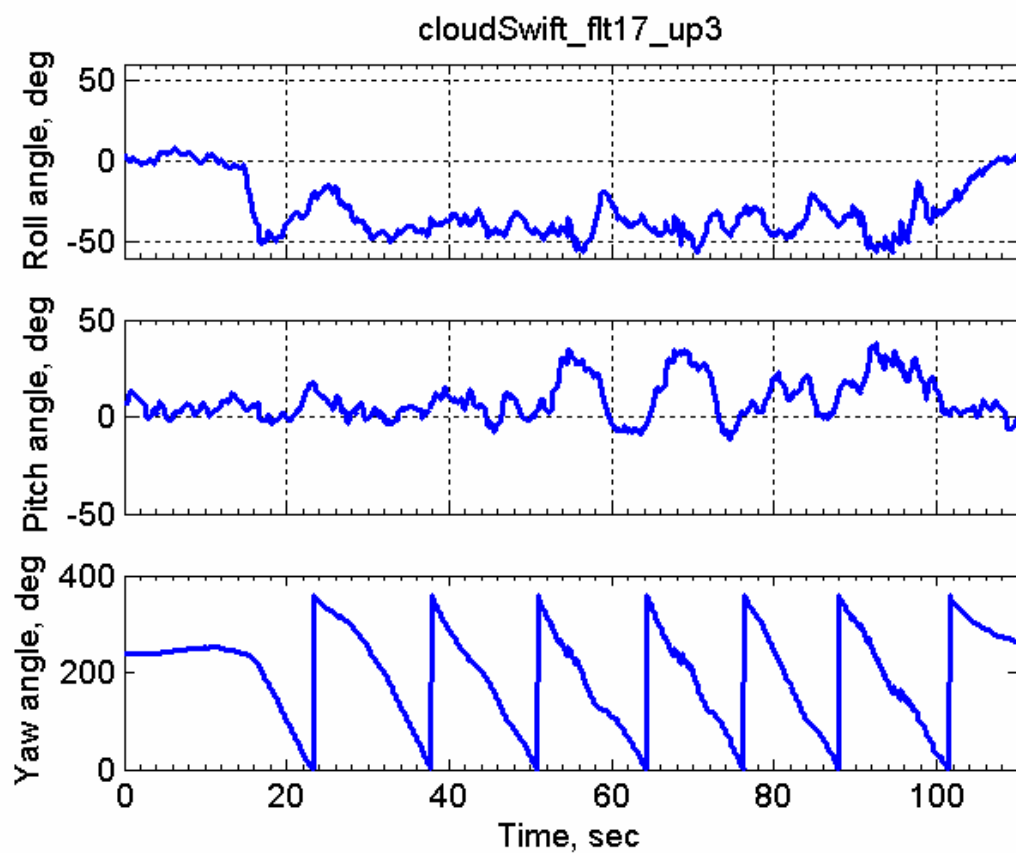
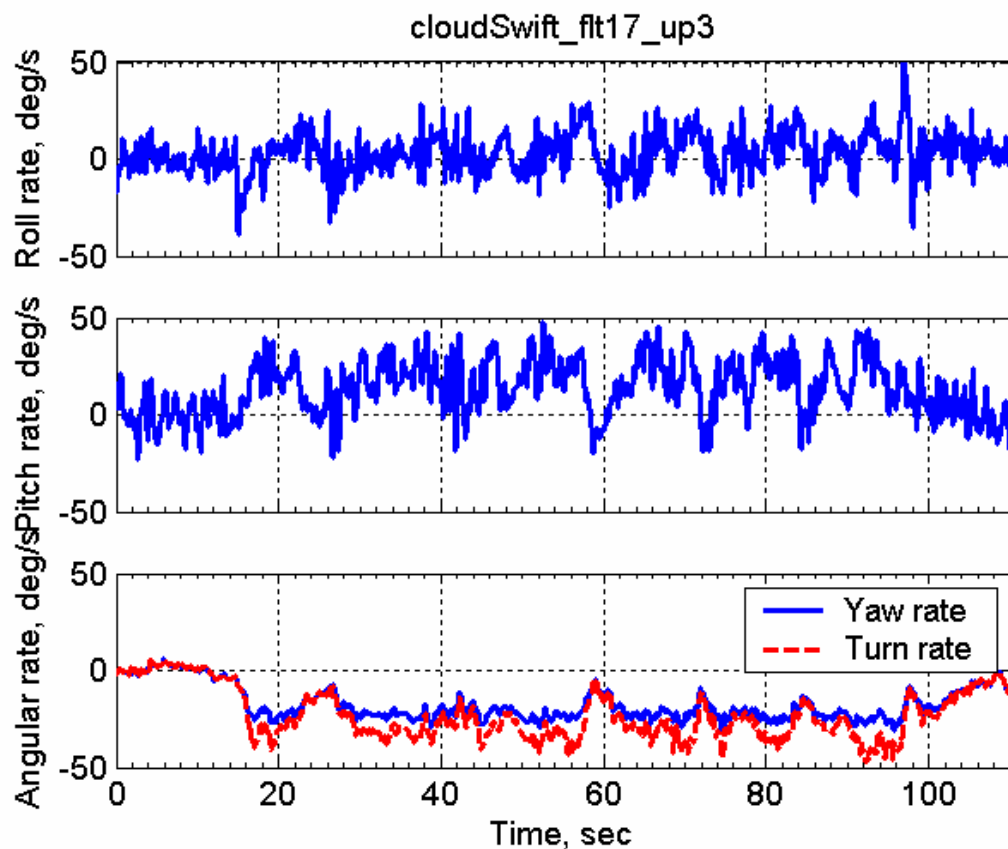
Flight 17, updraft 3

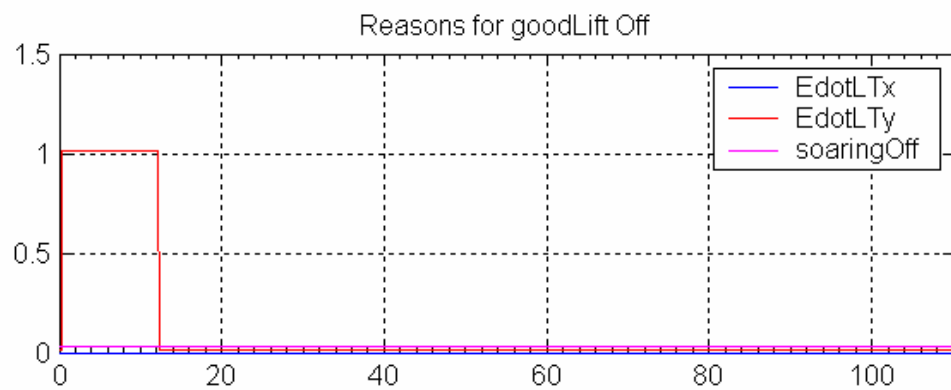
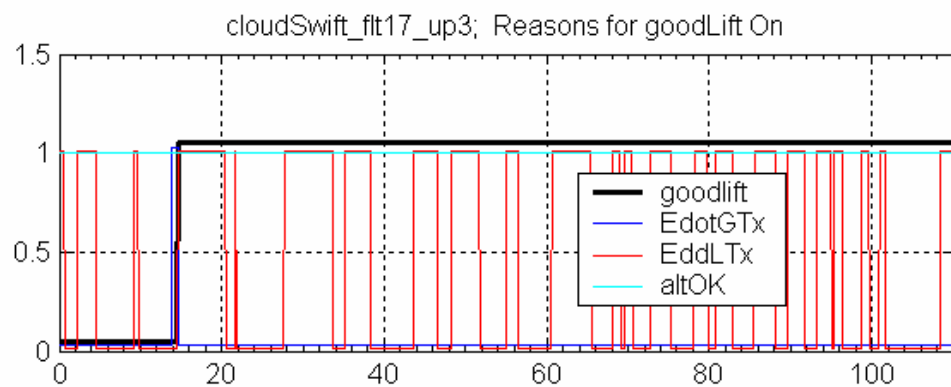
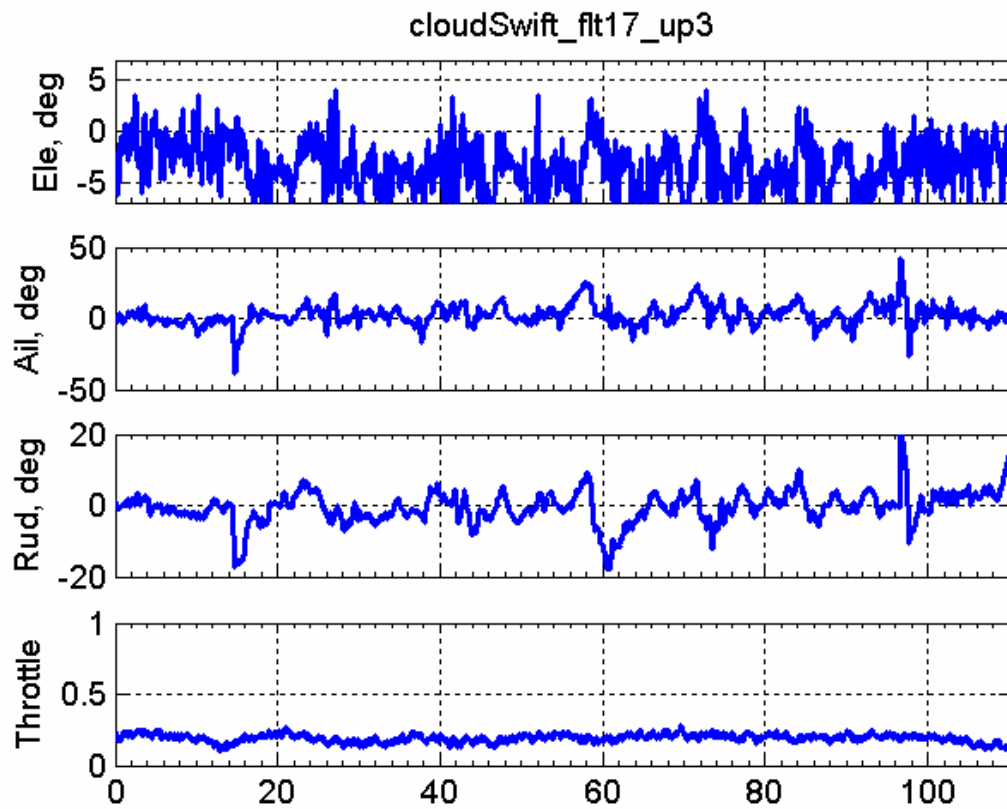
Week lift. Motor never off. Multiple GPS hits.

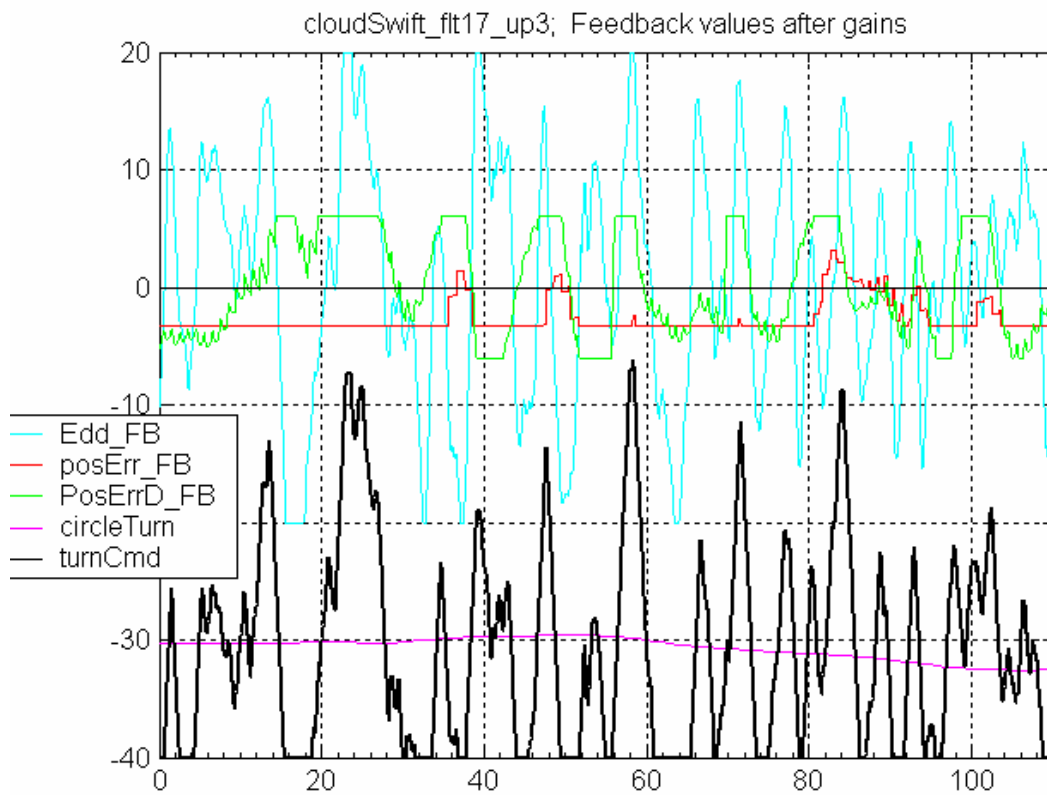
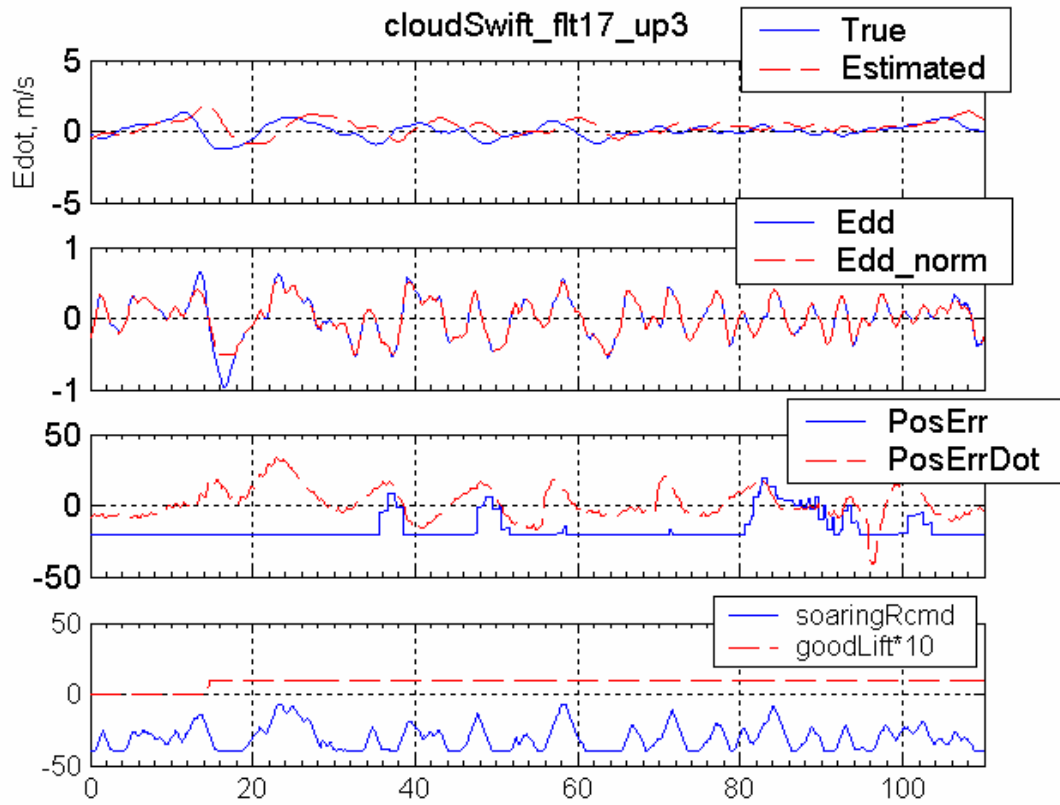






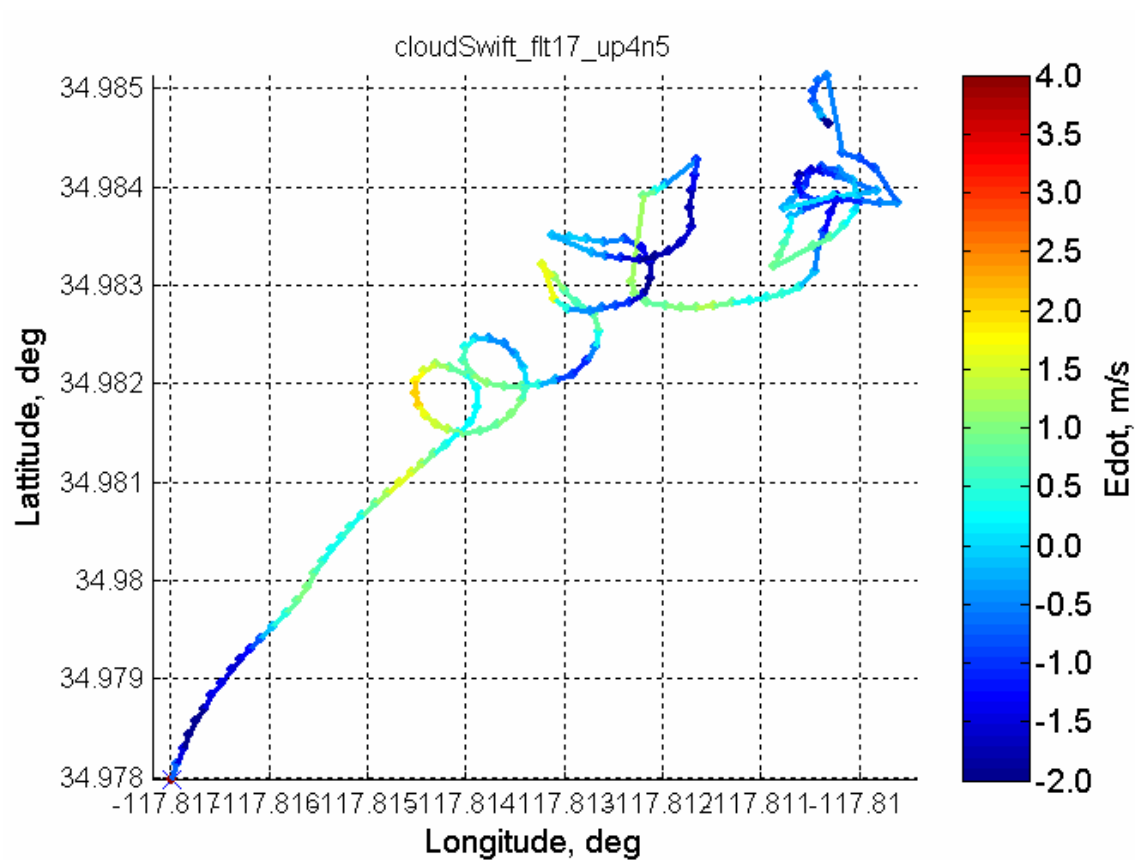


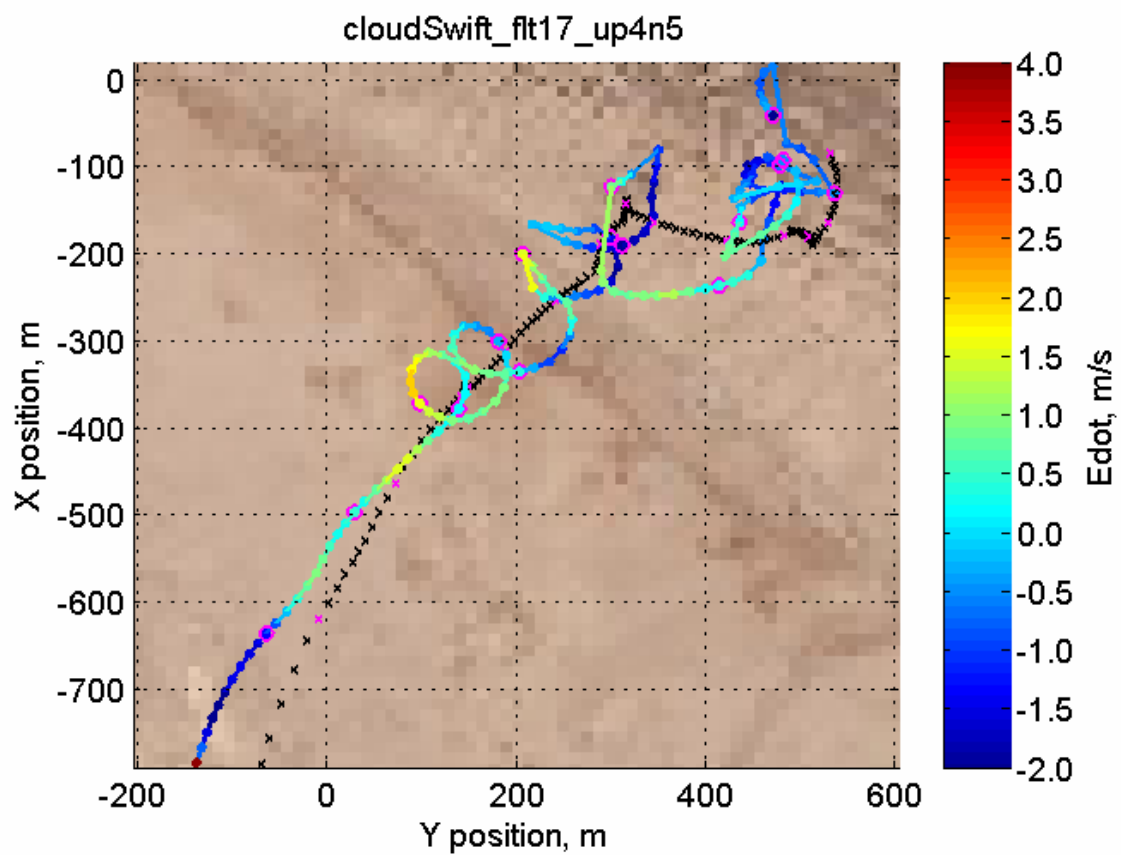
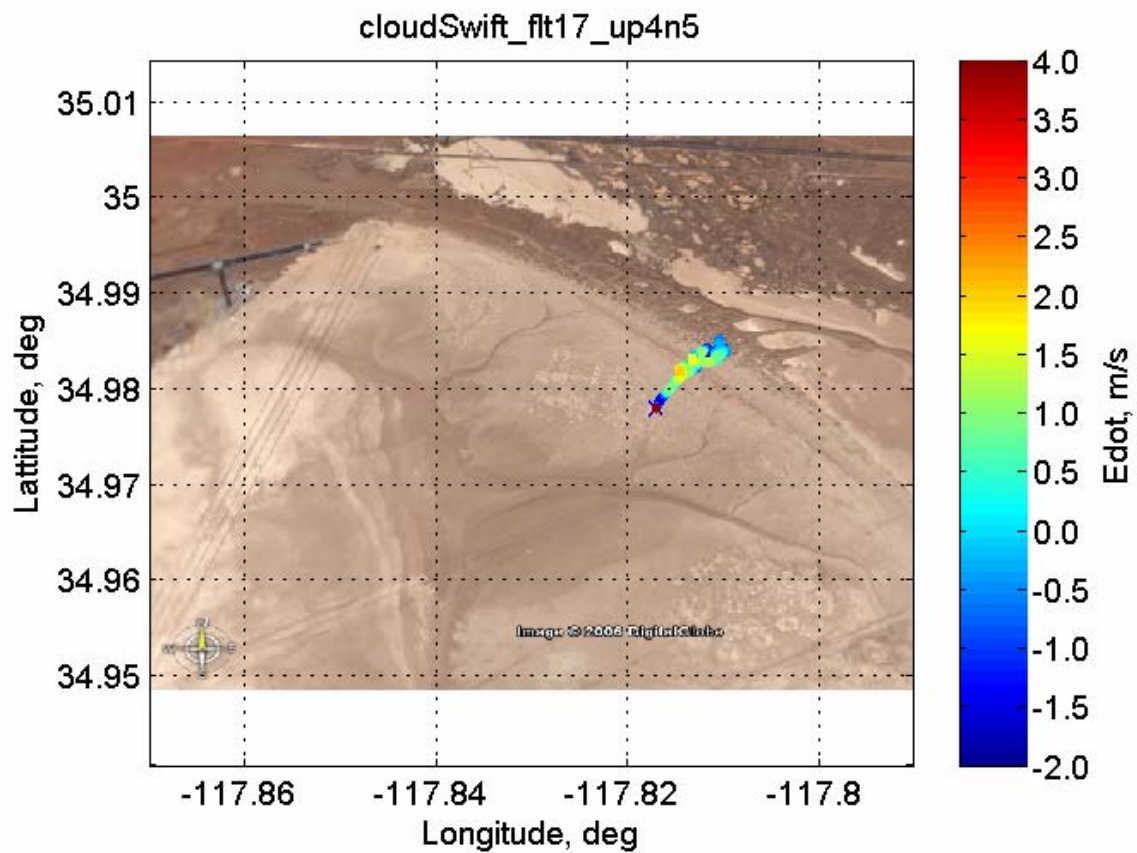


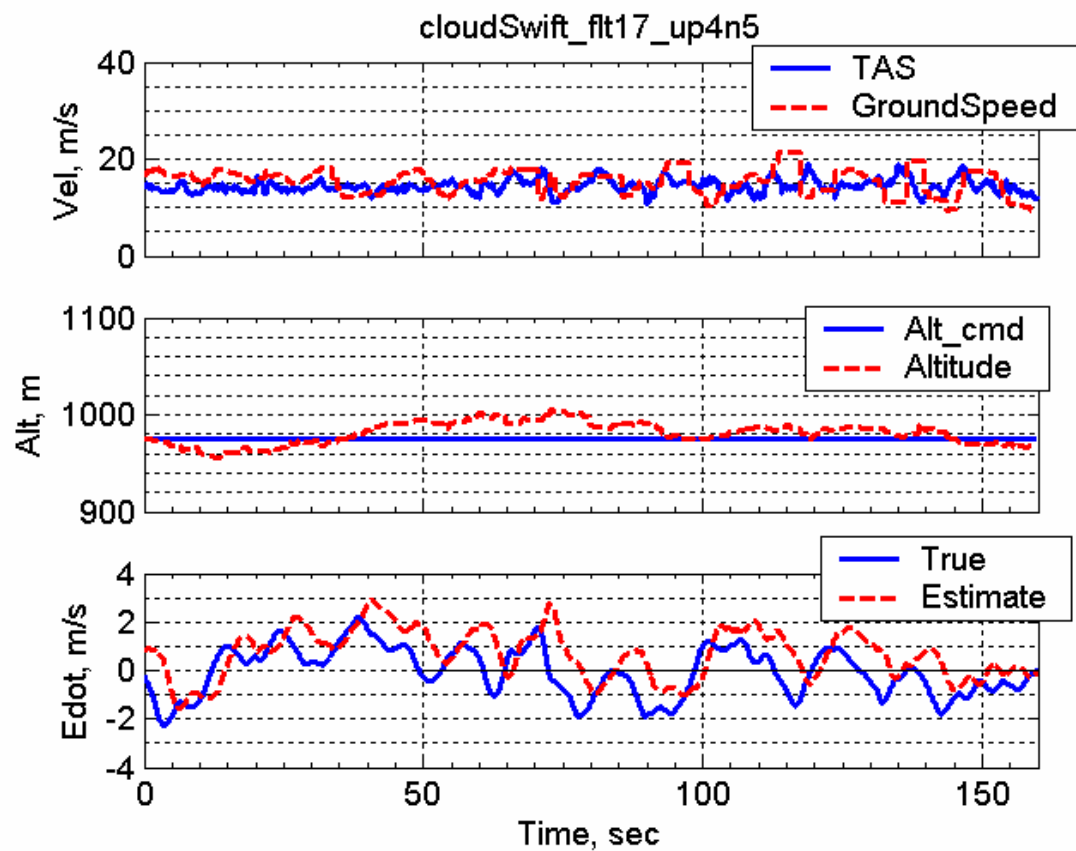
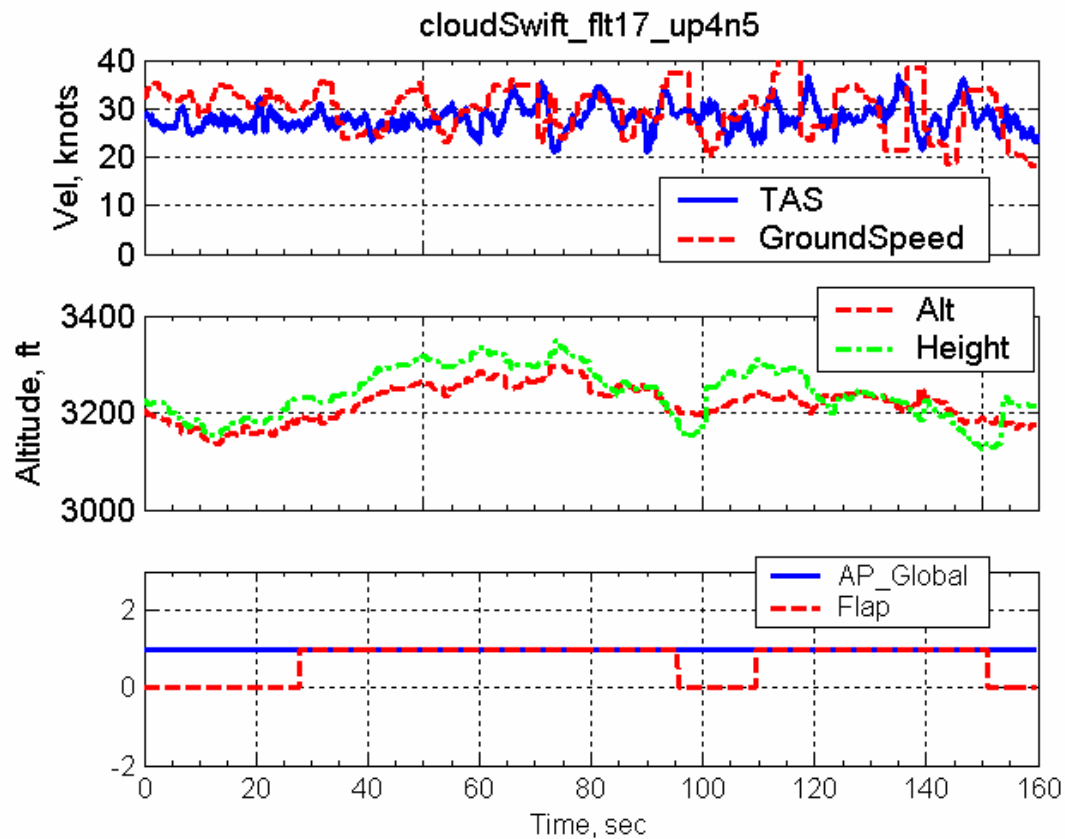


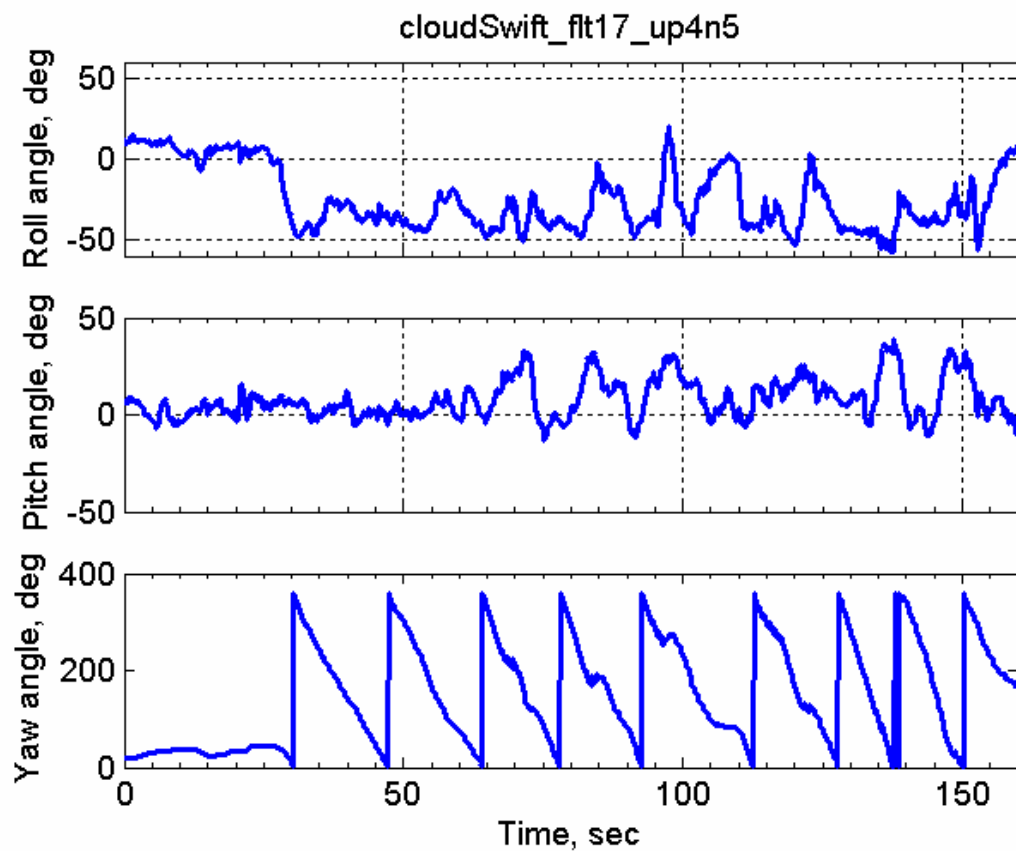
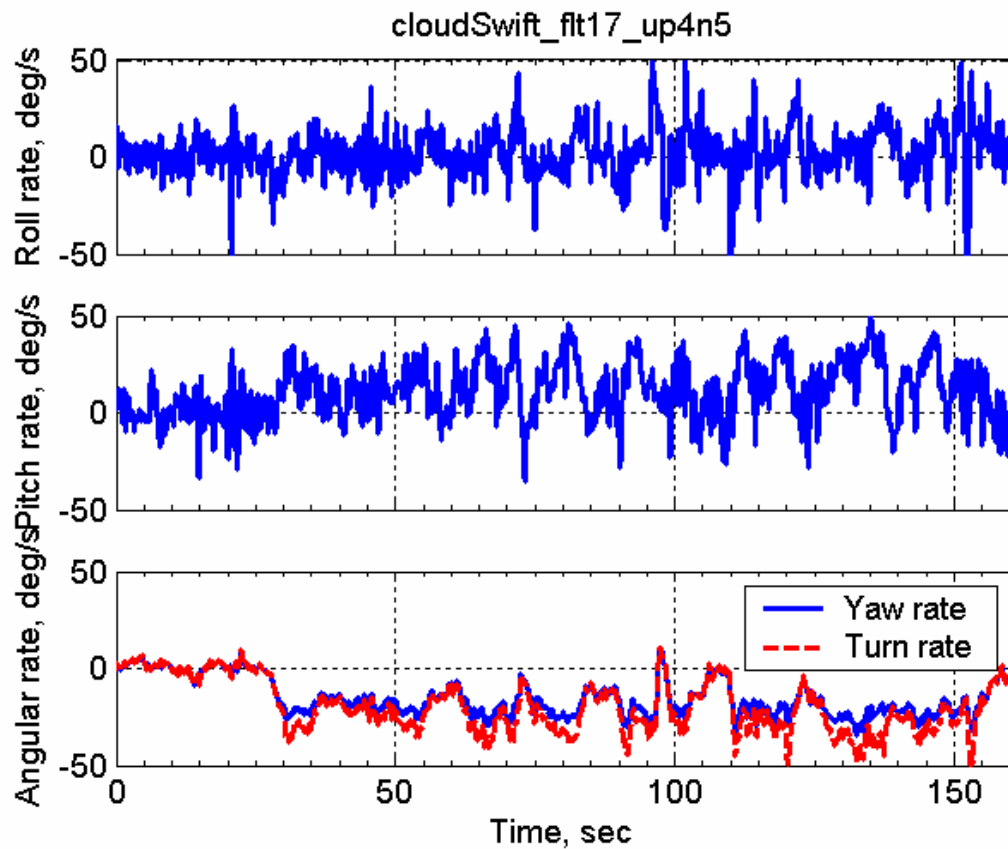
Flight 17, updrafts 4&5

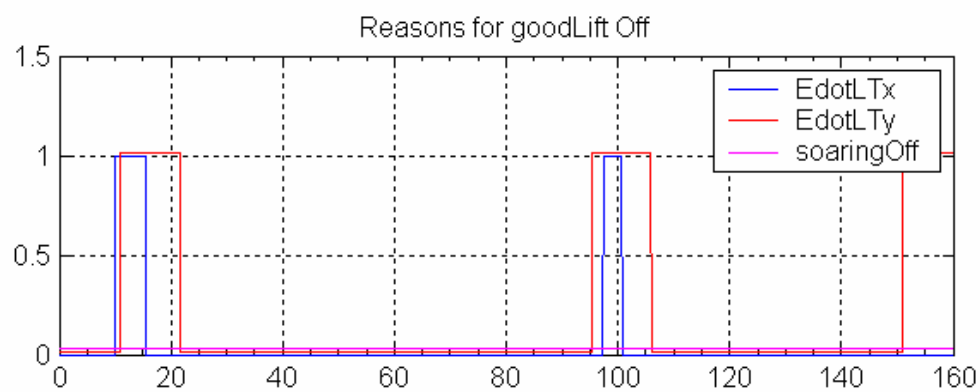
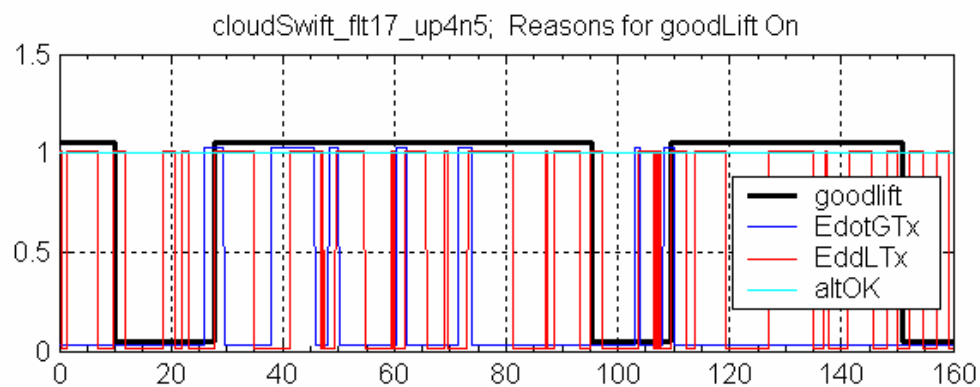
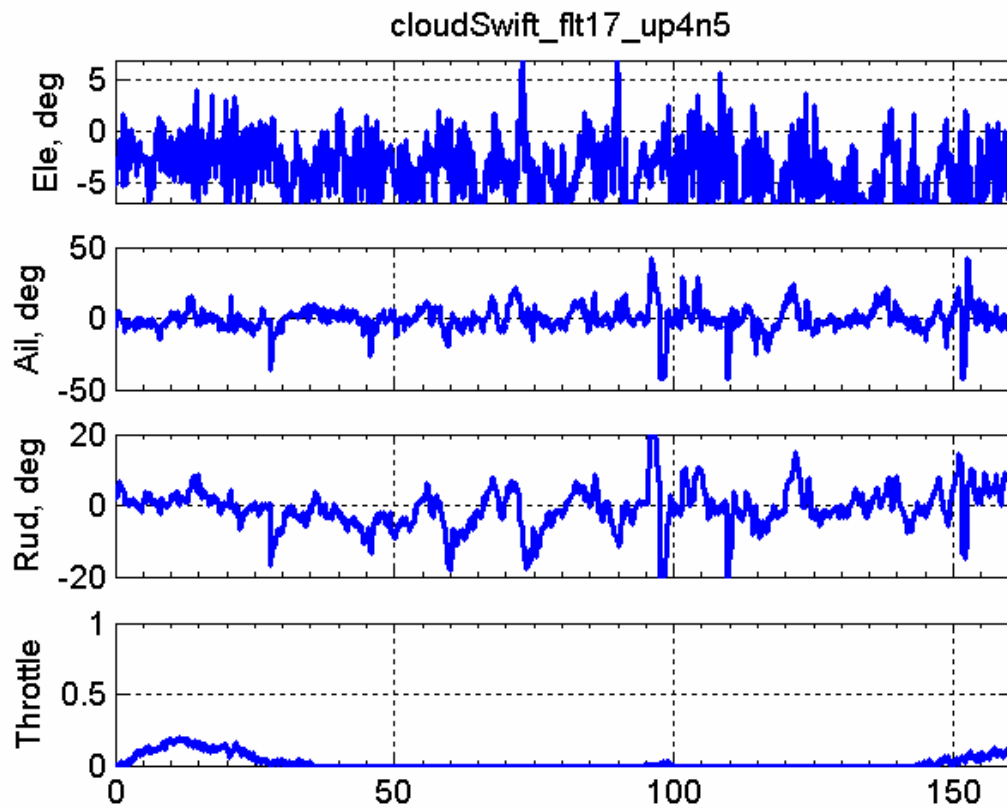
Multiple bad GPS hits.

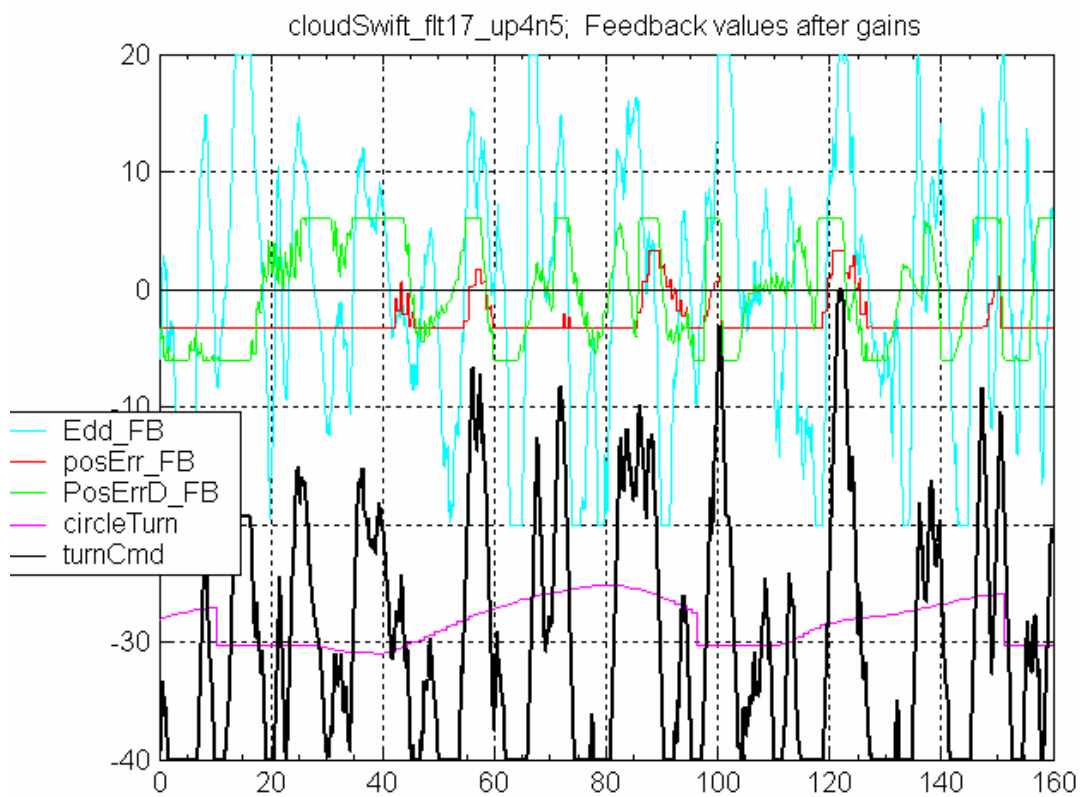
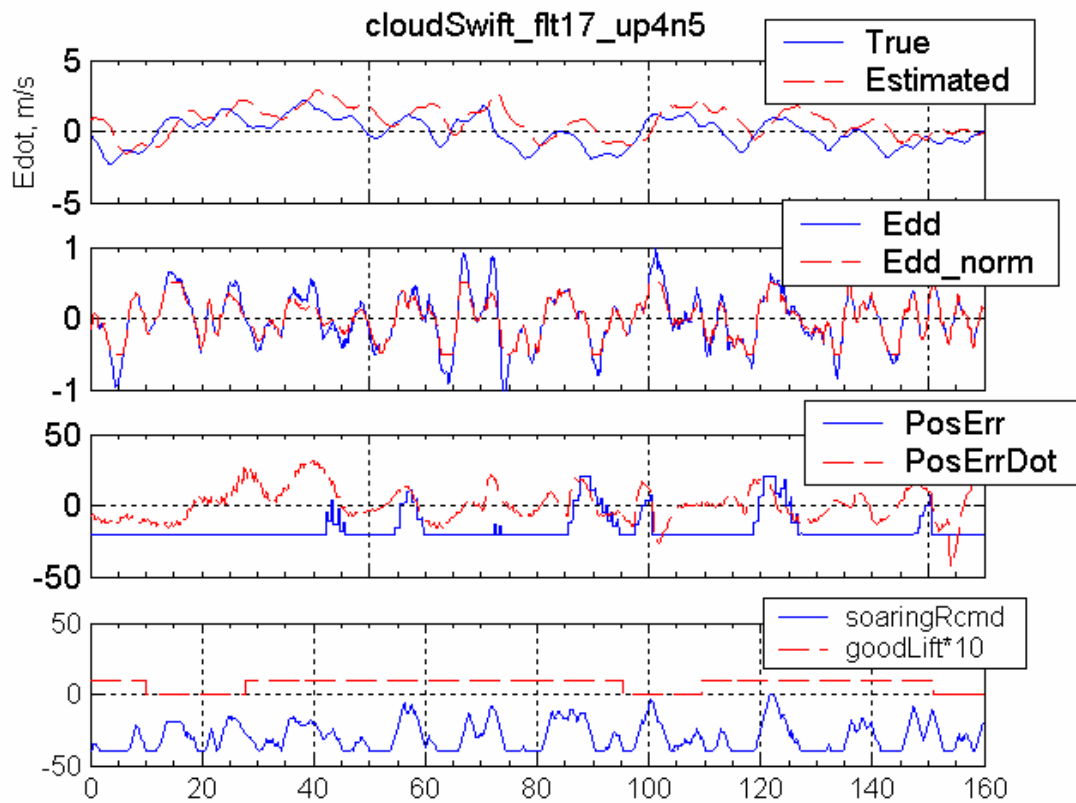






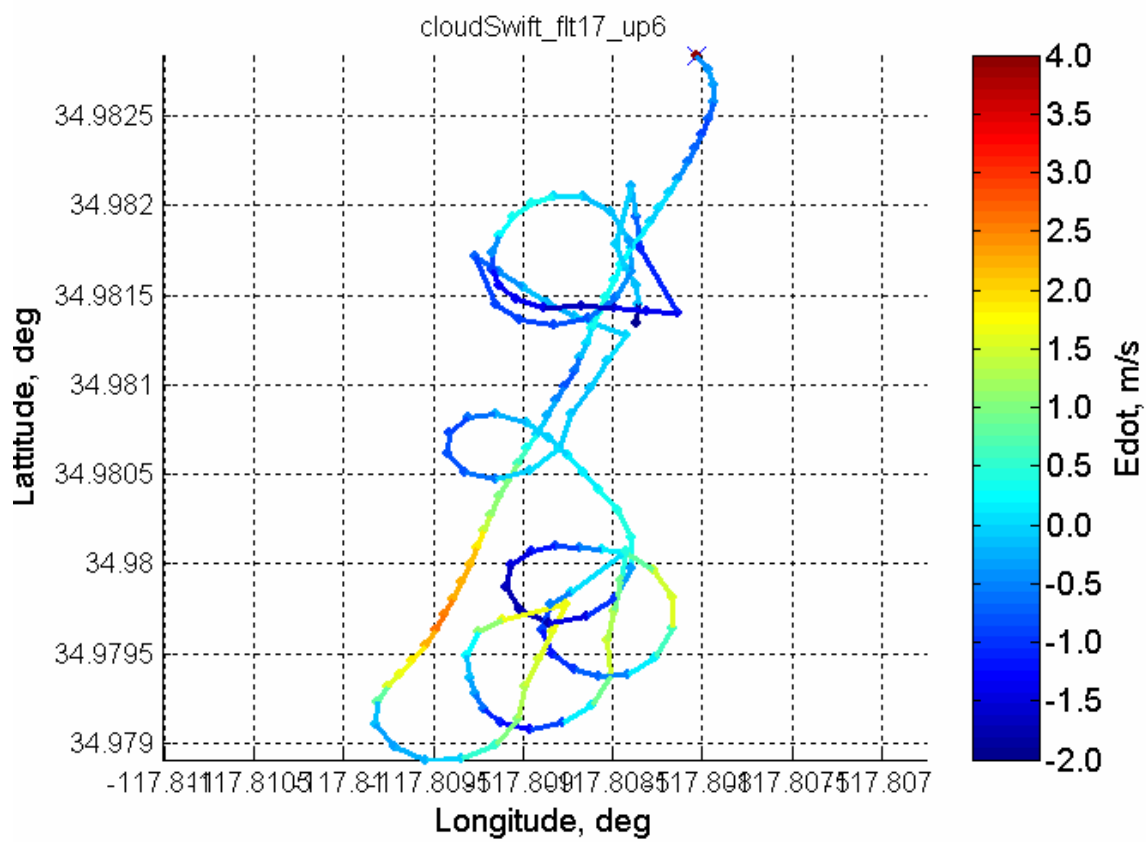


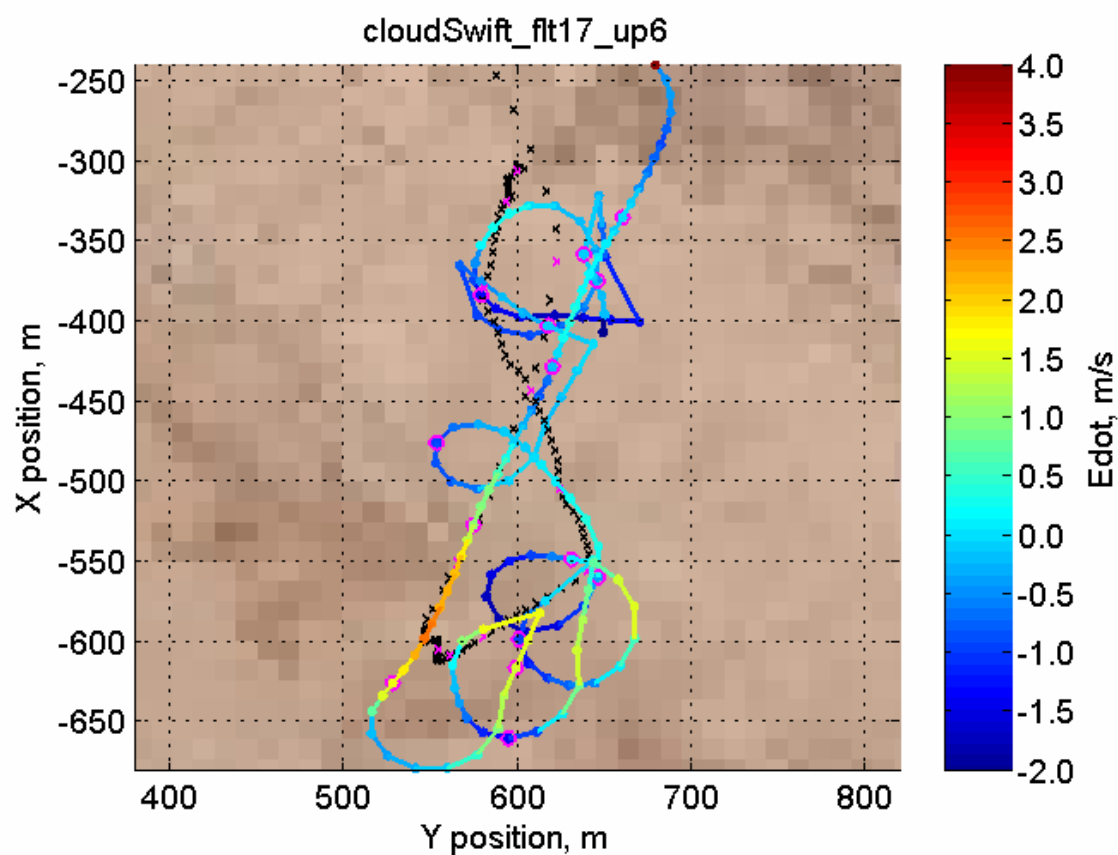
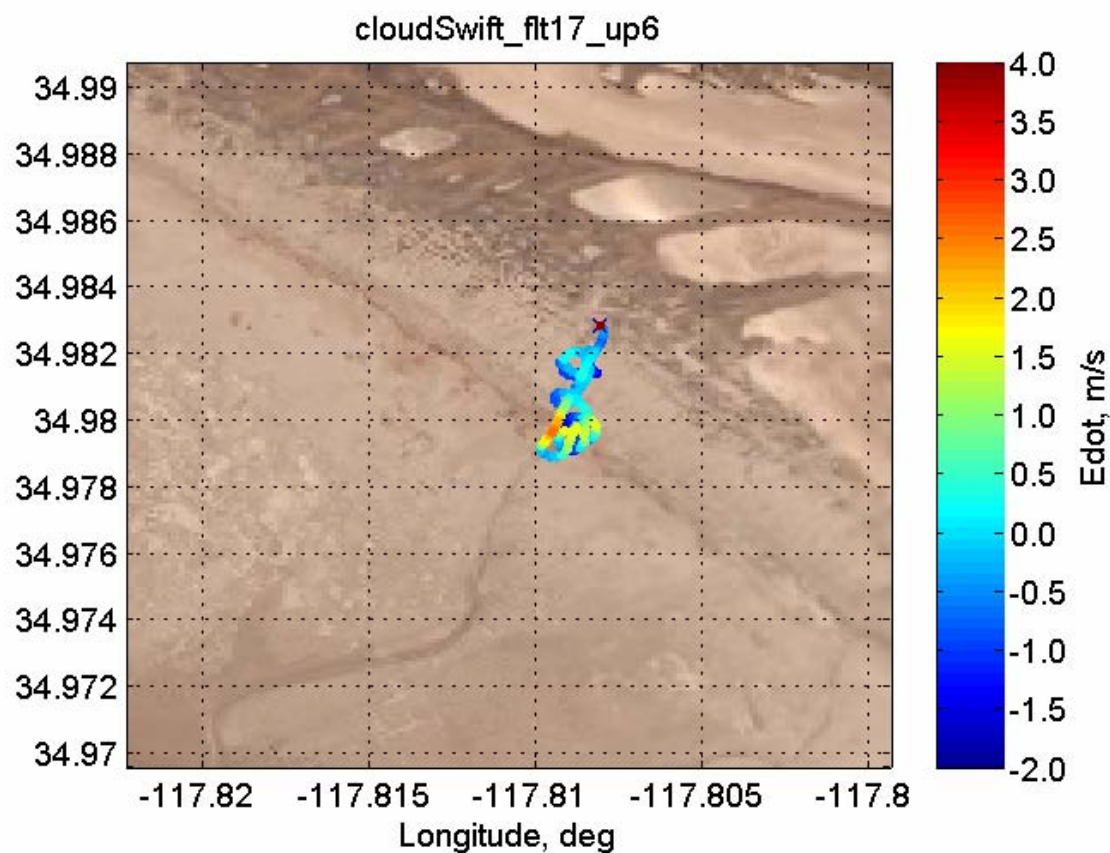


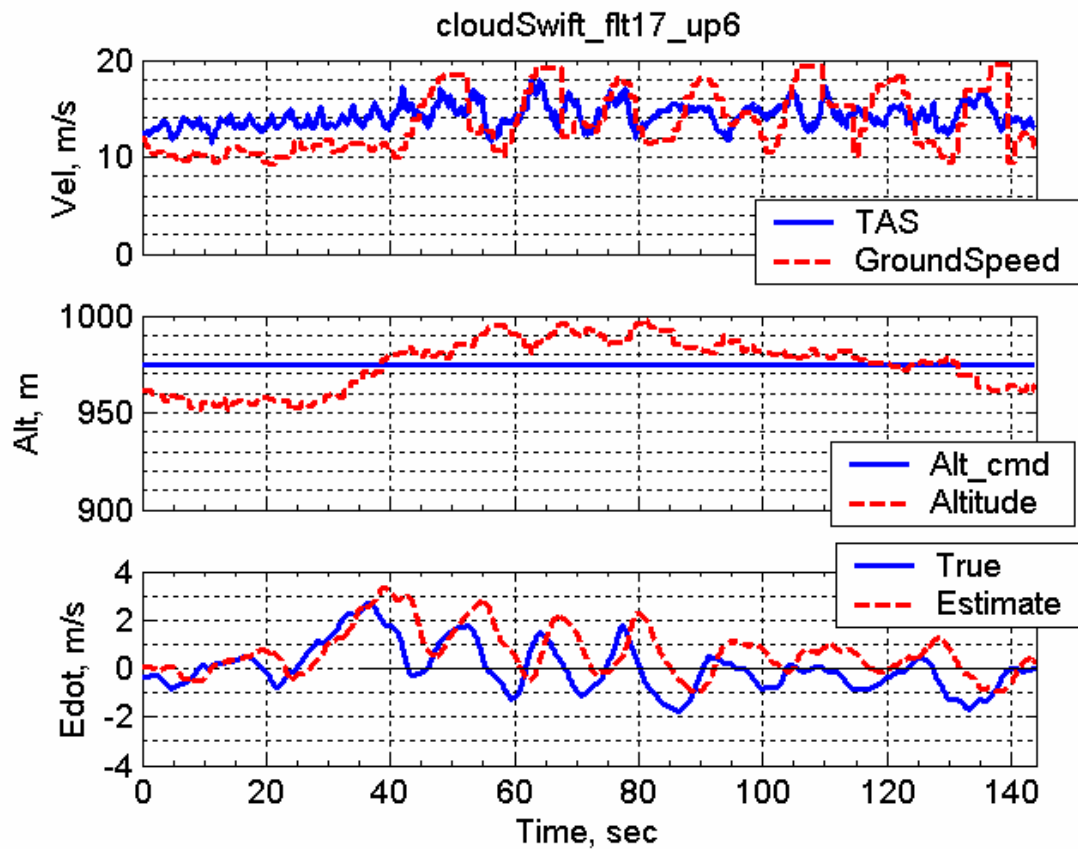
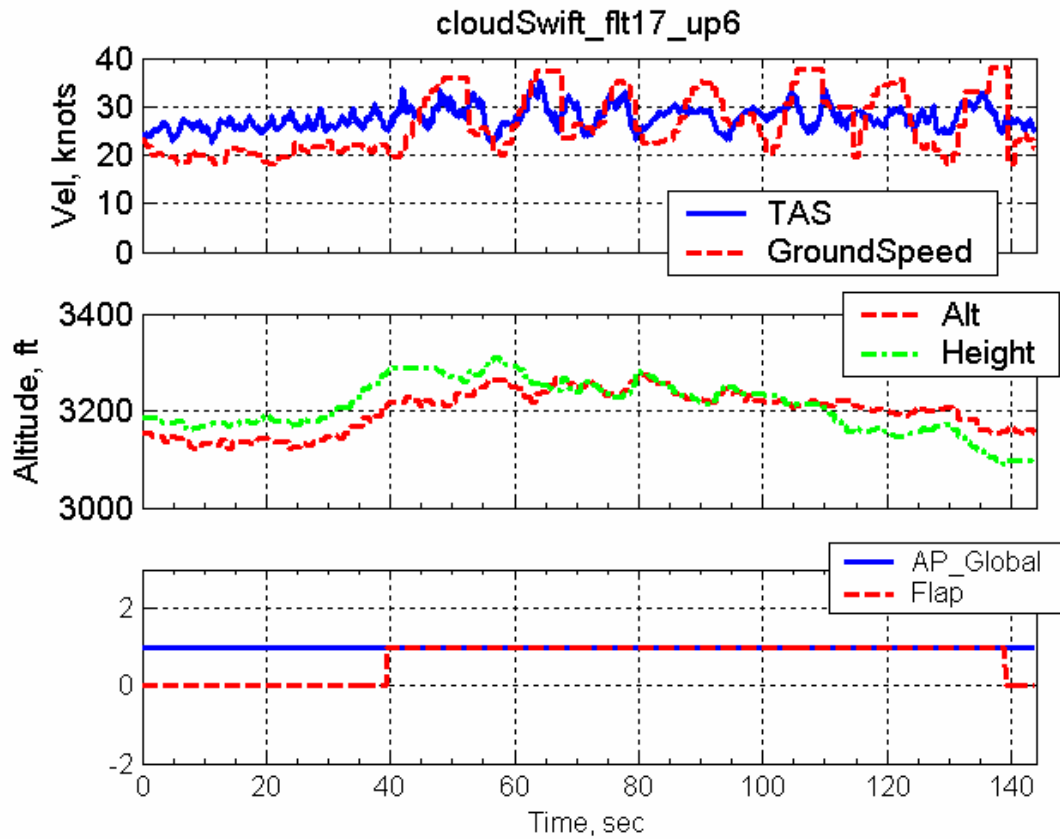


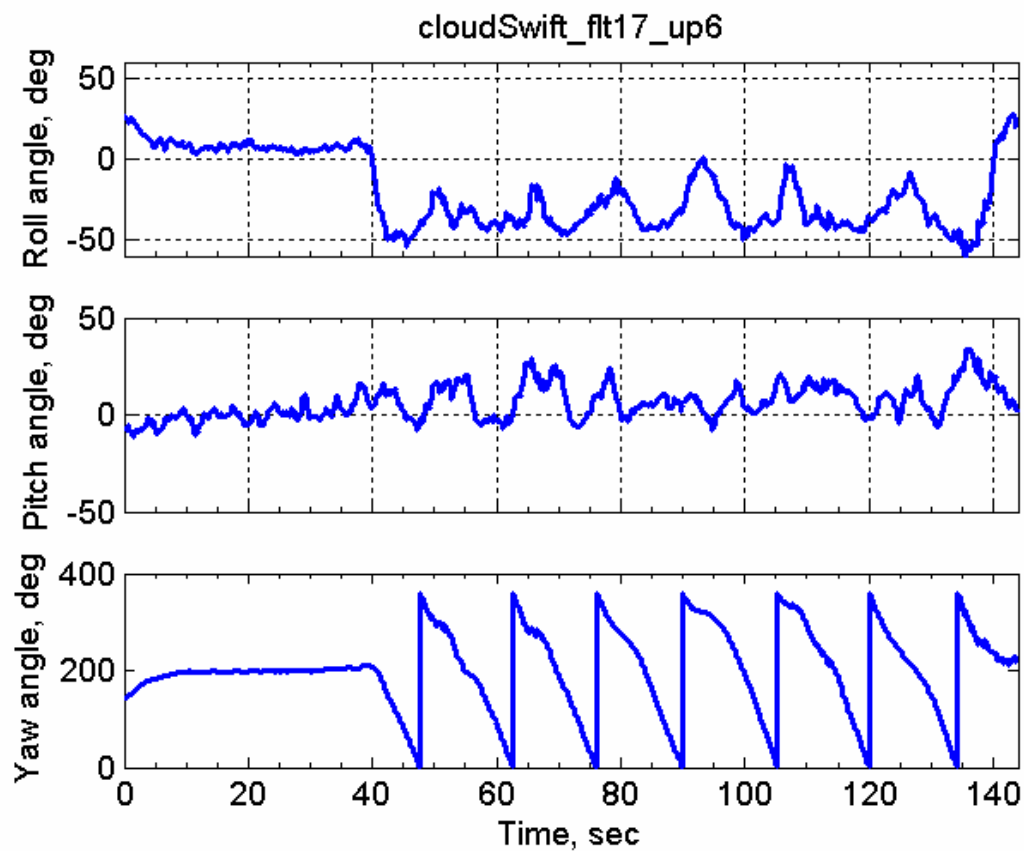
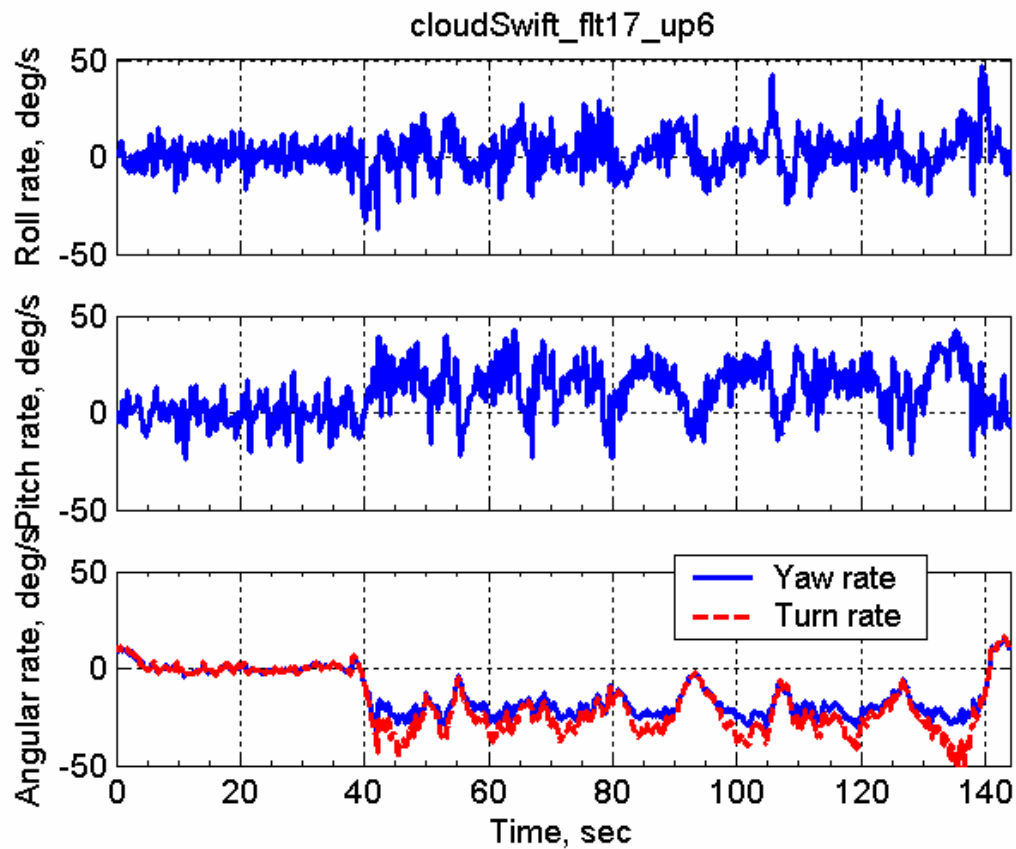
Flight 17, updraft 6

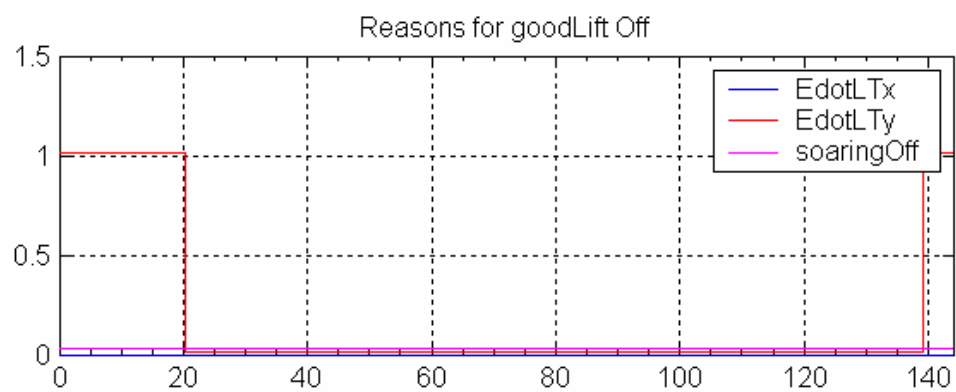
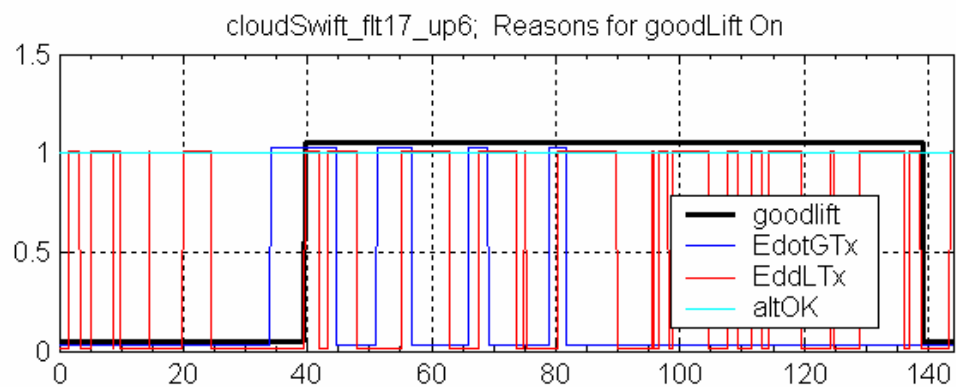
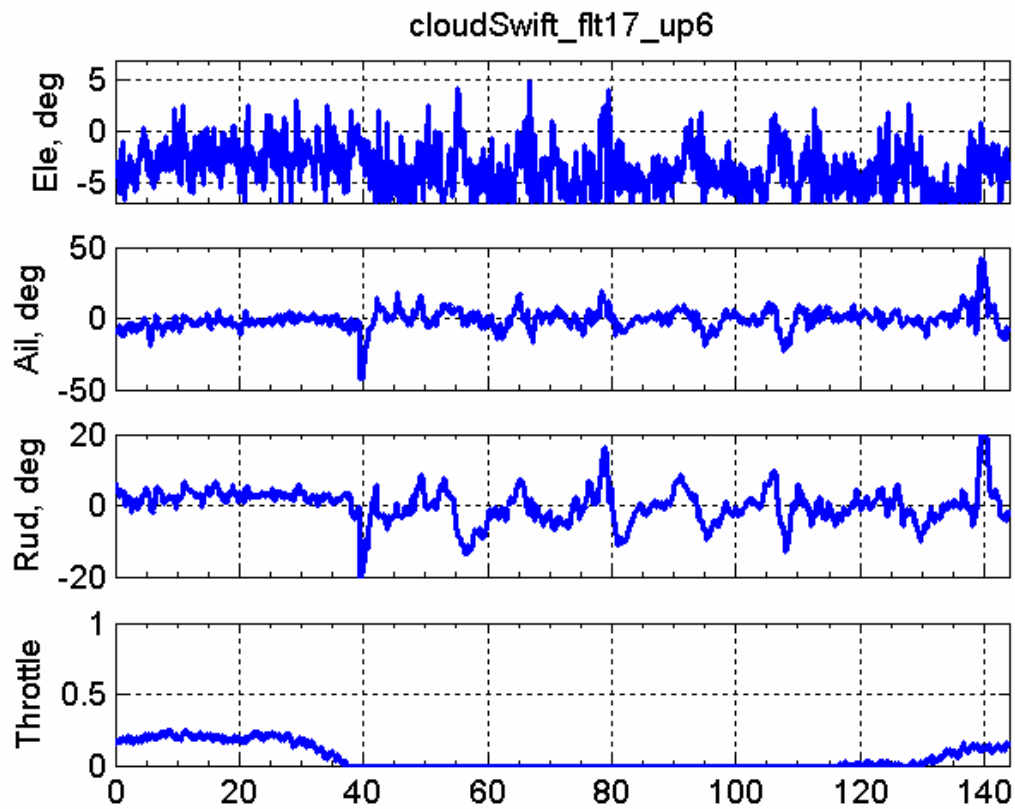
More GPS hits, still did OK

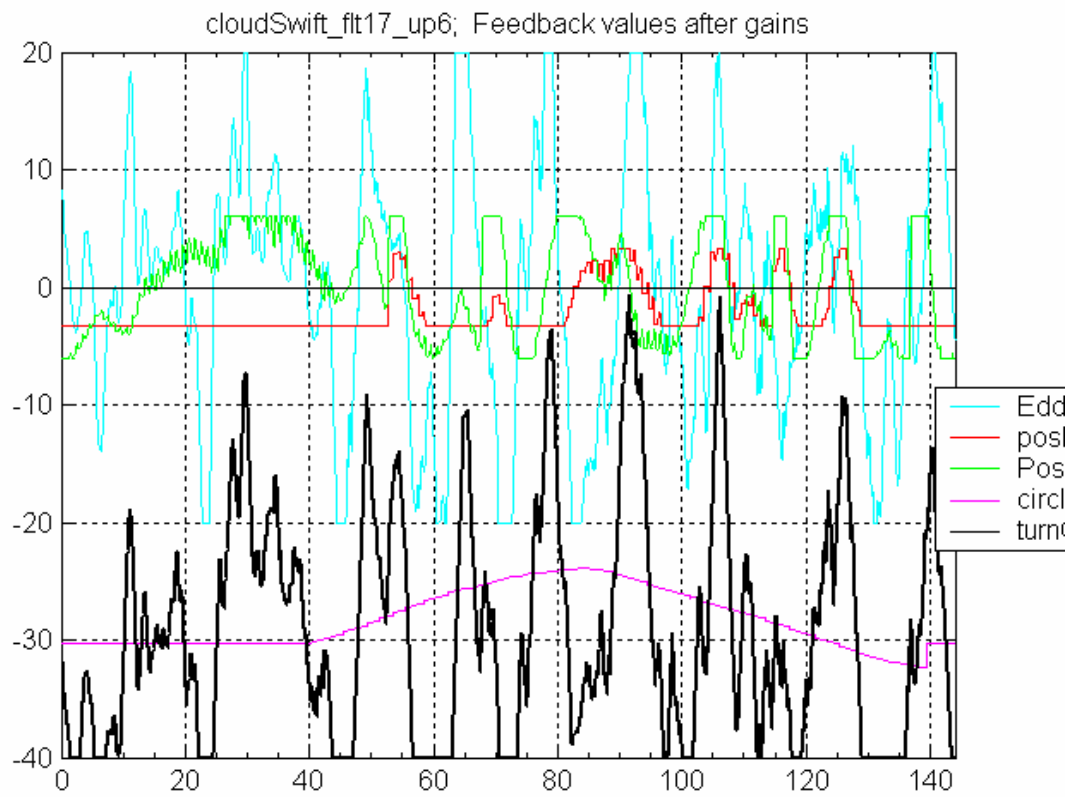
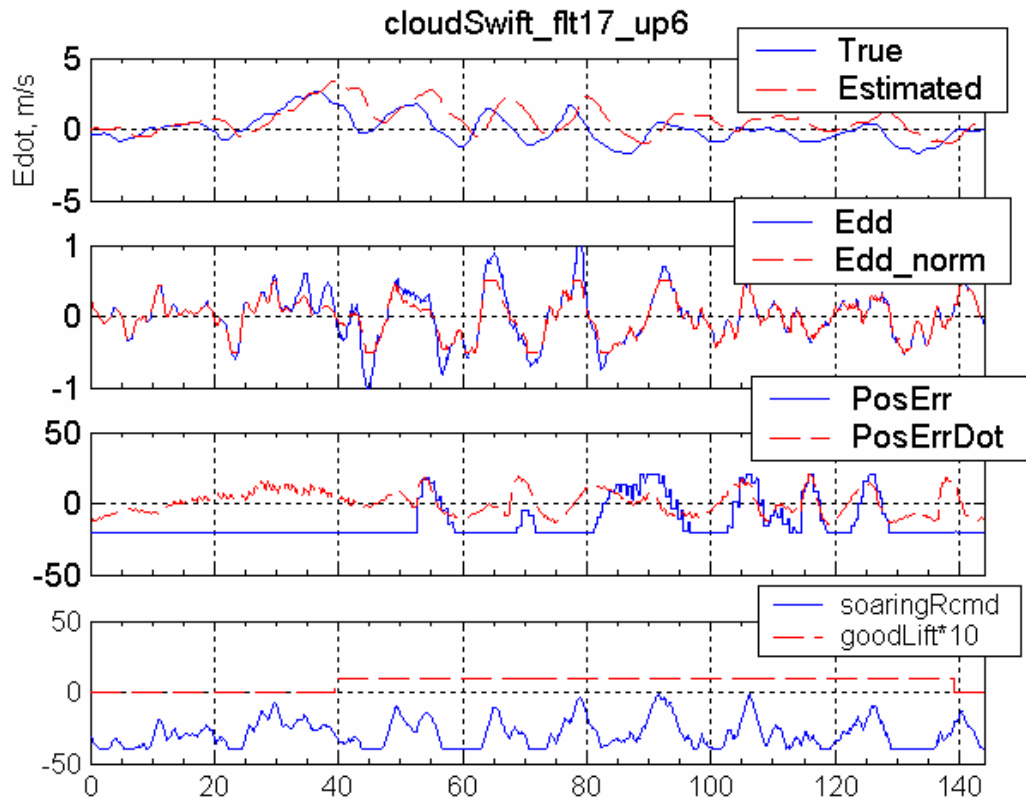






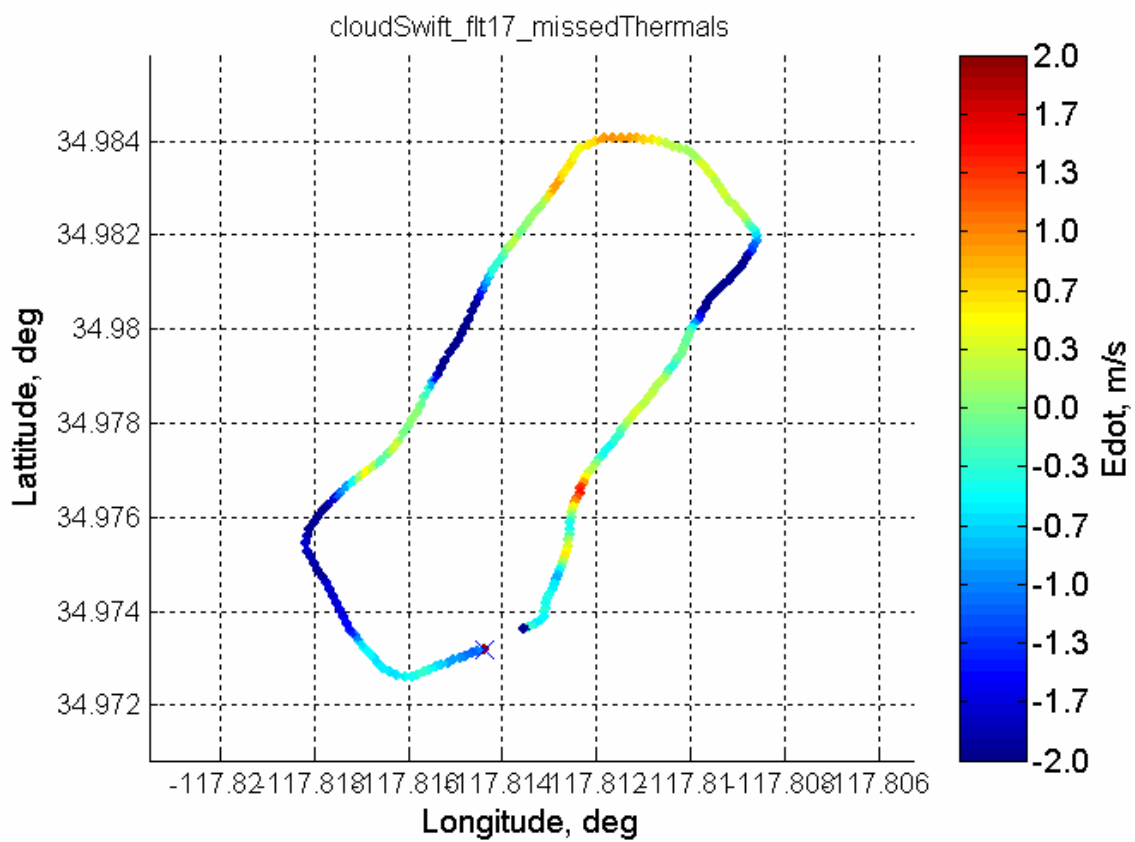


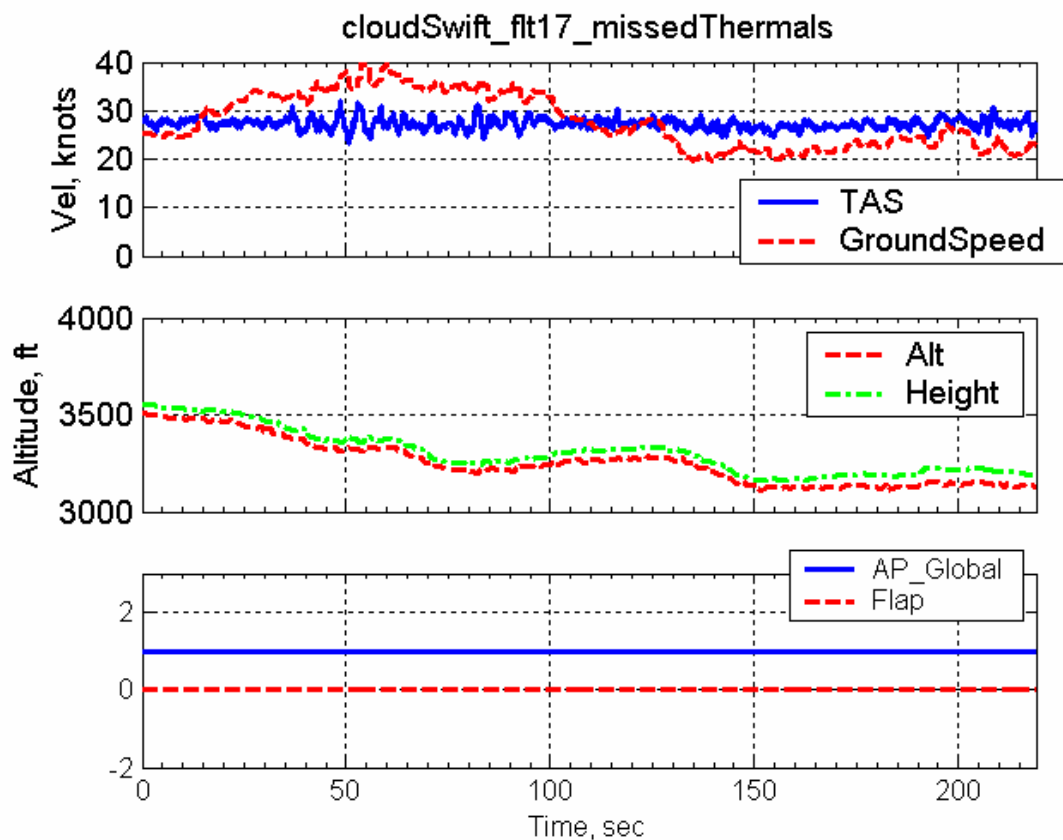
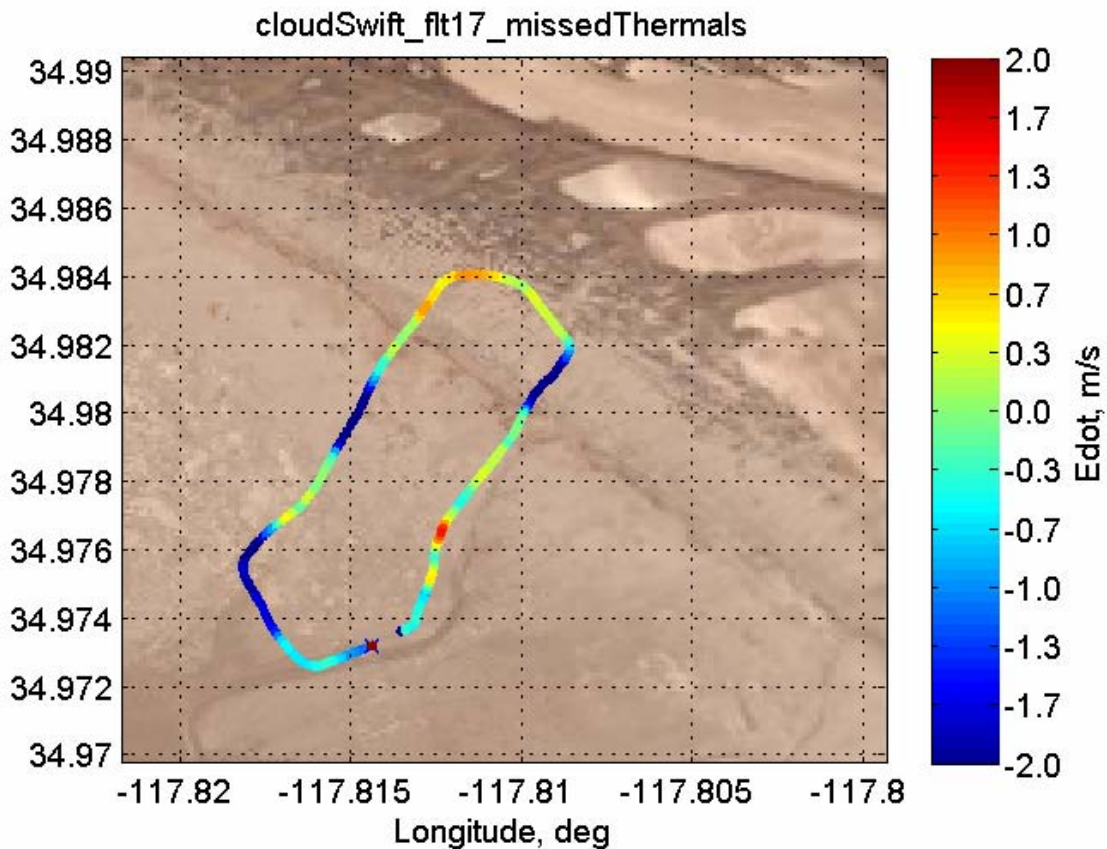


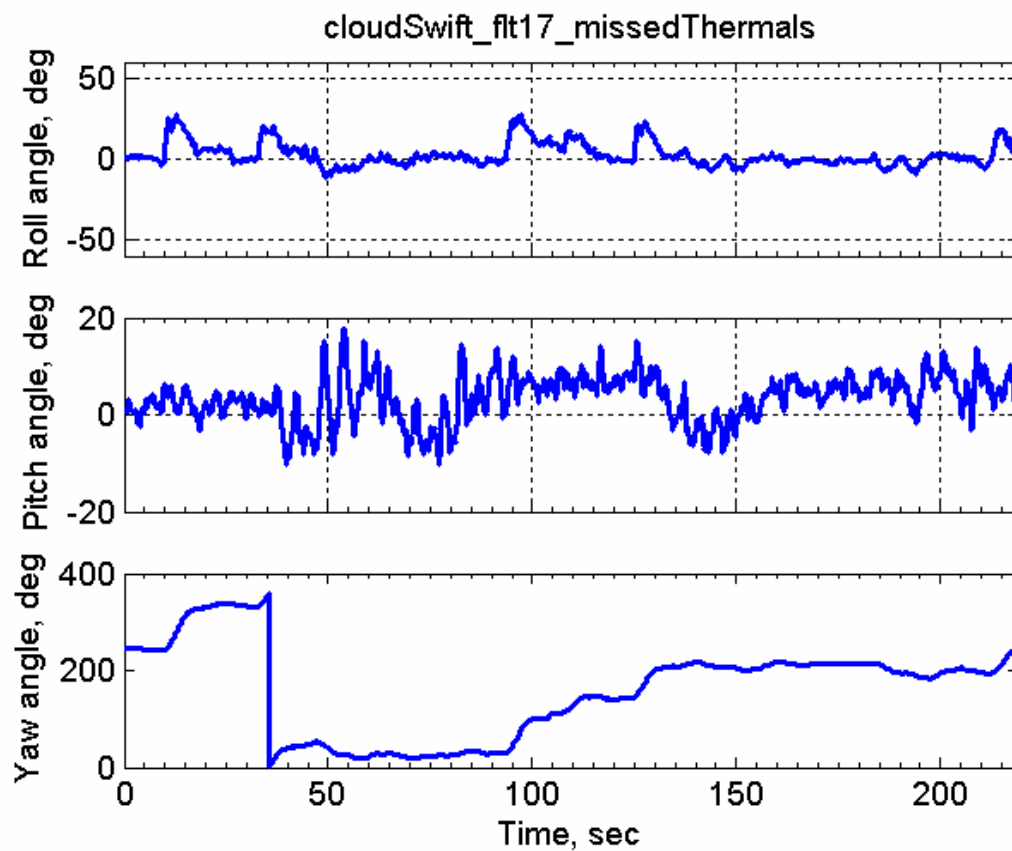
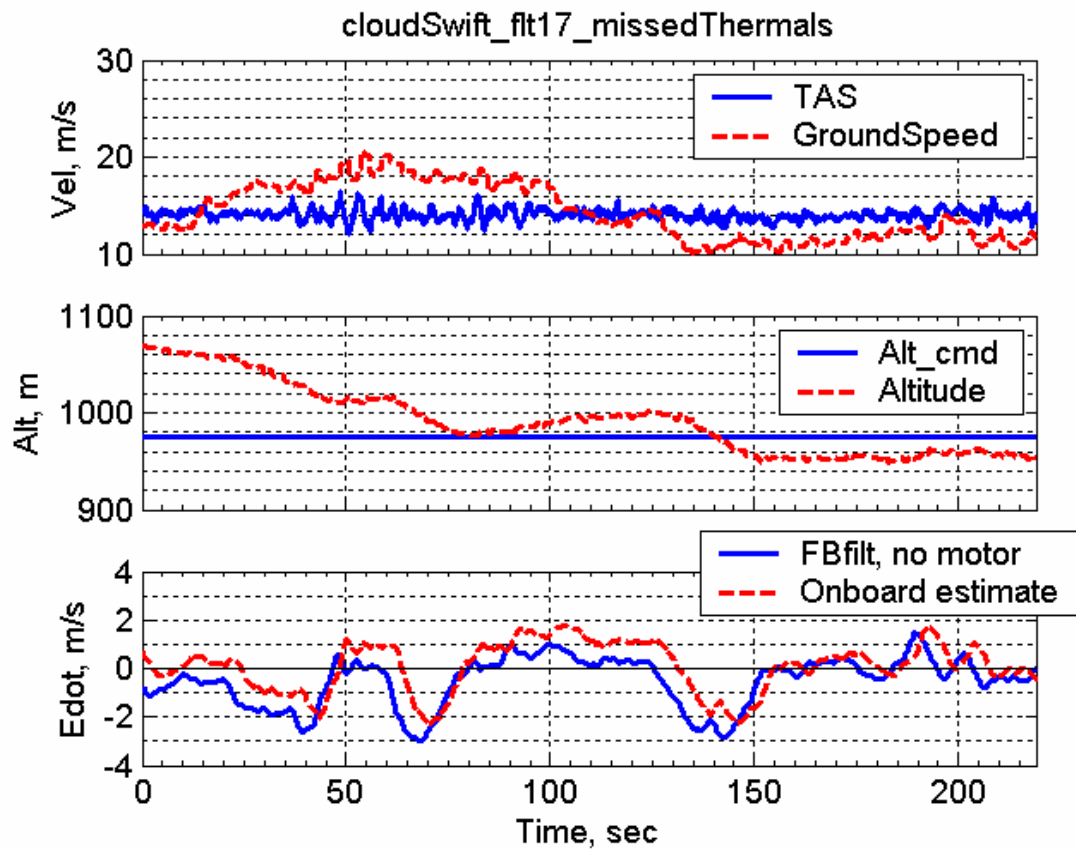


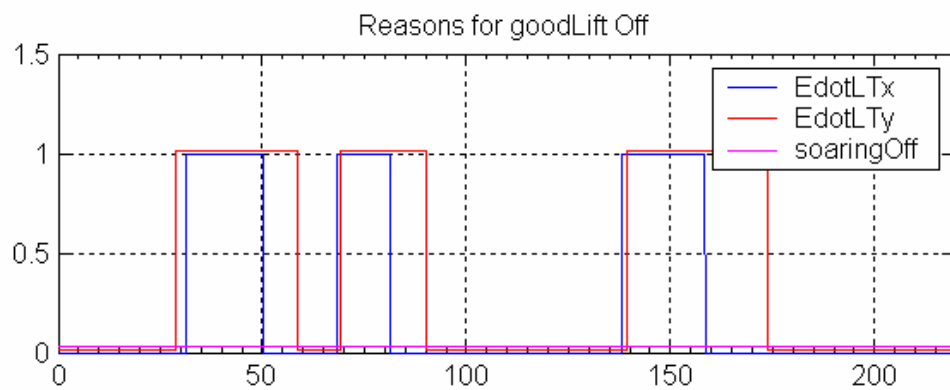
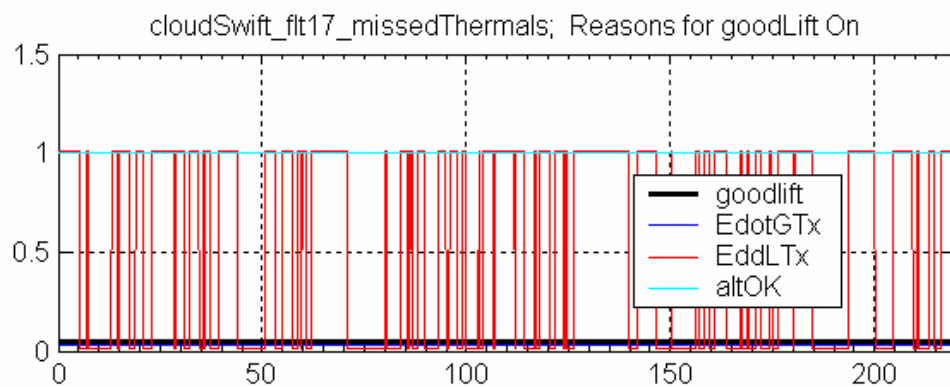
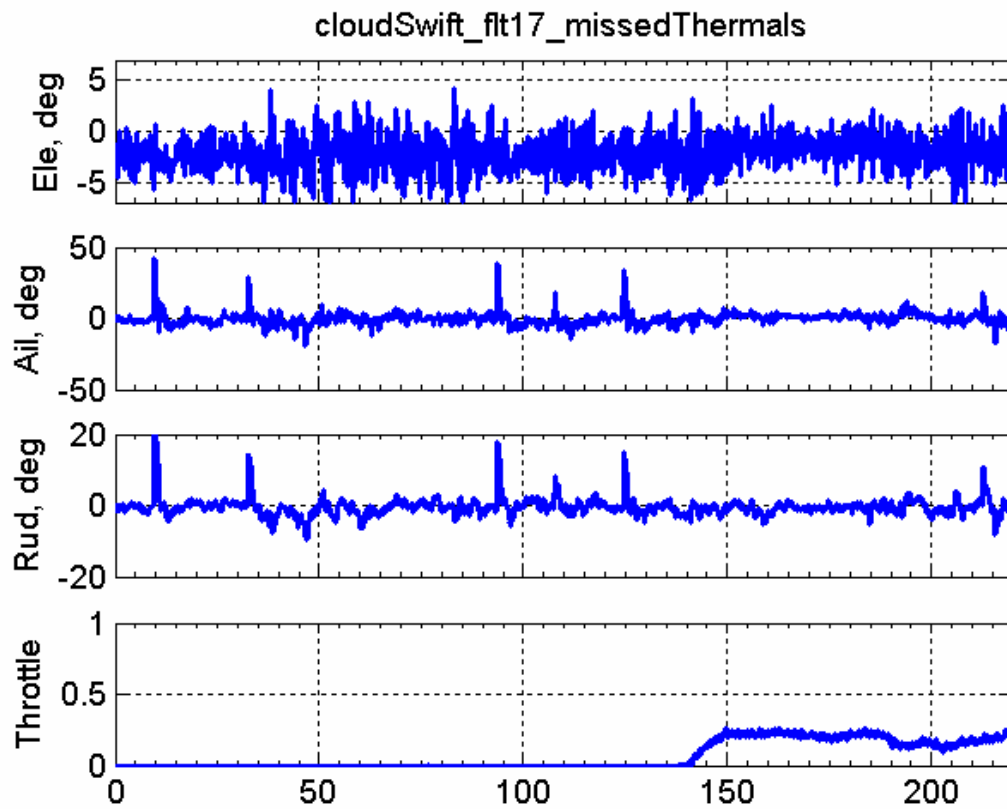
Flight 17, Missed Thermals

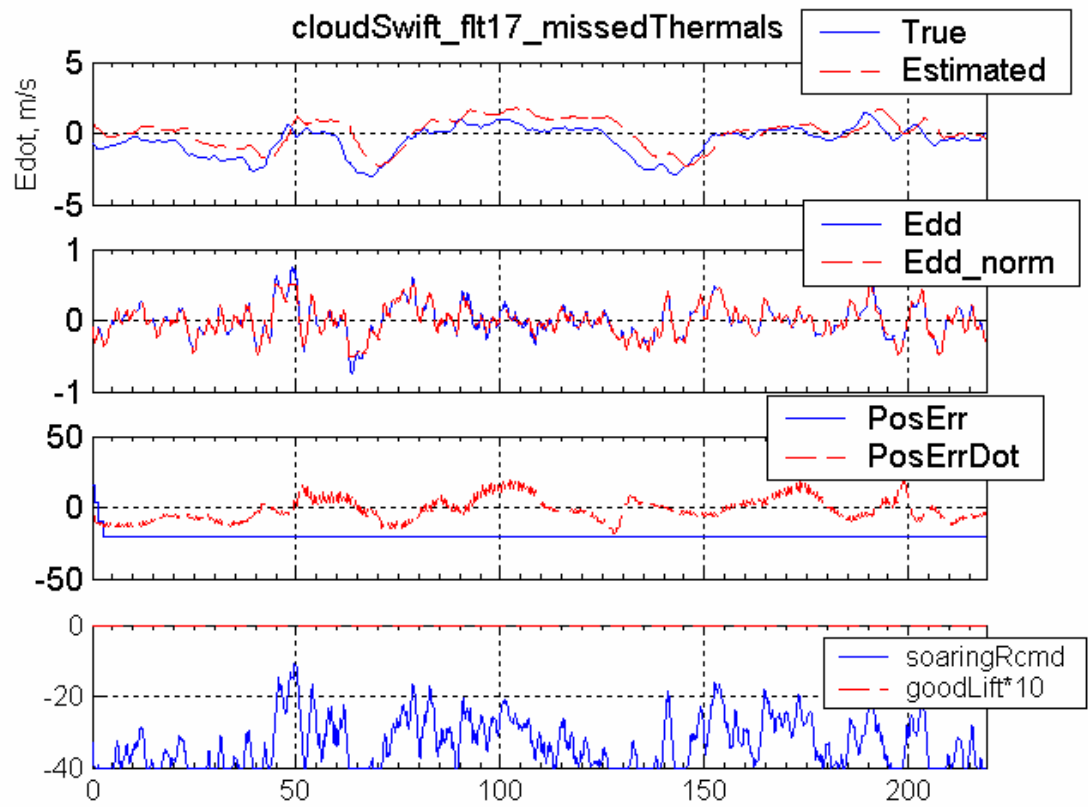
Trapedoidal shaped thermals. 1st updraft requires aileron deflection at entry and exit. These thermals should have been “investigated” before a decision was made to use it or not.











2006 Autonomous Soaring Project Flight Data Summary

Data collected in 2006 was performed to obtain data needed for parameter identification of the Cloud Swift Airframe. Data was taken in three sets:

- Inertial swings of the Cloud Swift-1 airframe.
- Checkout flight of new Piccolo software, gps antenna, speed controller, and propeller, using the Cloud Swift-1 airframe.
- PID flights with the Cloud Swift-2 airframe.

Data comes from three sources: The Piccolo telemetry stream, the Piccolo doublet files, and the Calspan Miniaturized Flight Data Recorder System (MFDRS). When possible, data from all three sources was blended together.

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1.1 Inertia Swing Data

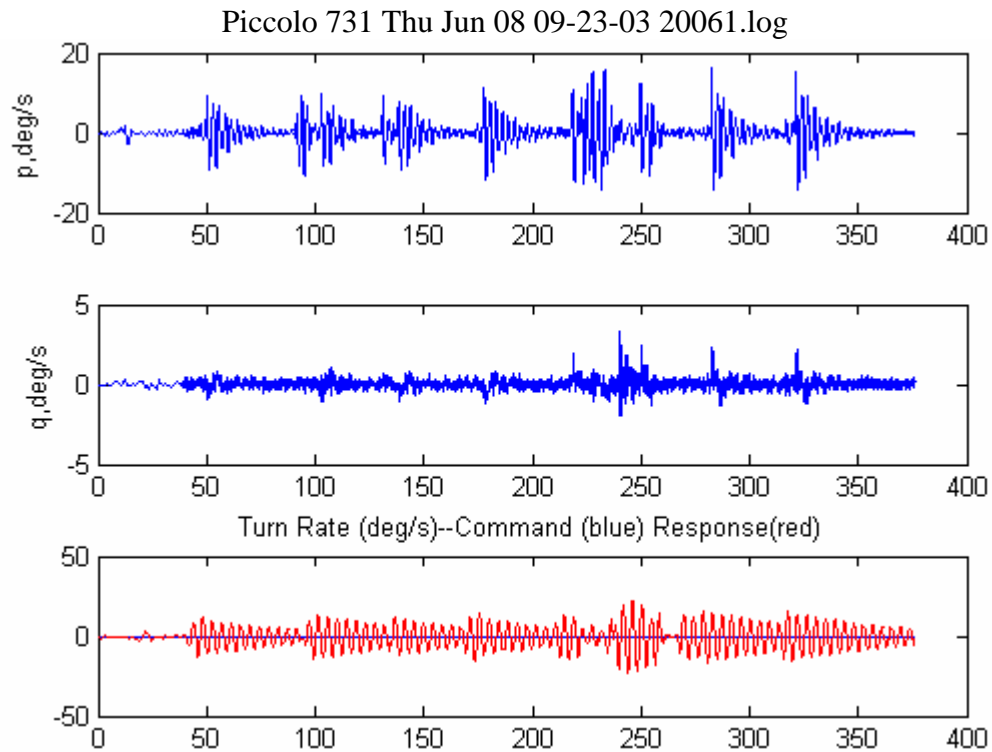
Inertia swings were conducted with the Cloud Swift-1 airframe. The Piccolo was used to record data while the aircraft rotated while being suspended from cables. The aircraft was configured with a Piccolo-2 autopilot, helix gps antenna, 90A speed controller, 6000mAh 5-cell lithium motor battery, 2000mAh lithium 3-cell Piccolo battery, 2000mAh 2-cell lithium servo battery, FTS pallet in the nose, and communications antenna in the tail. The aircraft was held by a custom-made aluminum box that bolted to the fuselage. Final inertias were found by subtracting the calculated inertia of the box from the measured total inertias. See notes to obtain the exact configuration of each test.

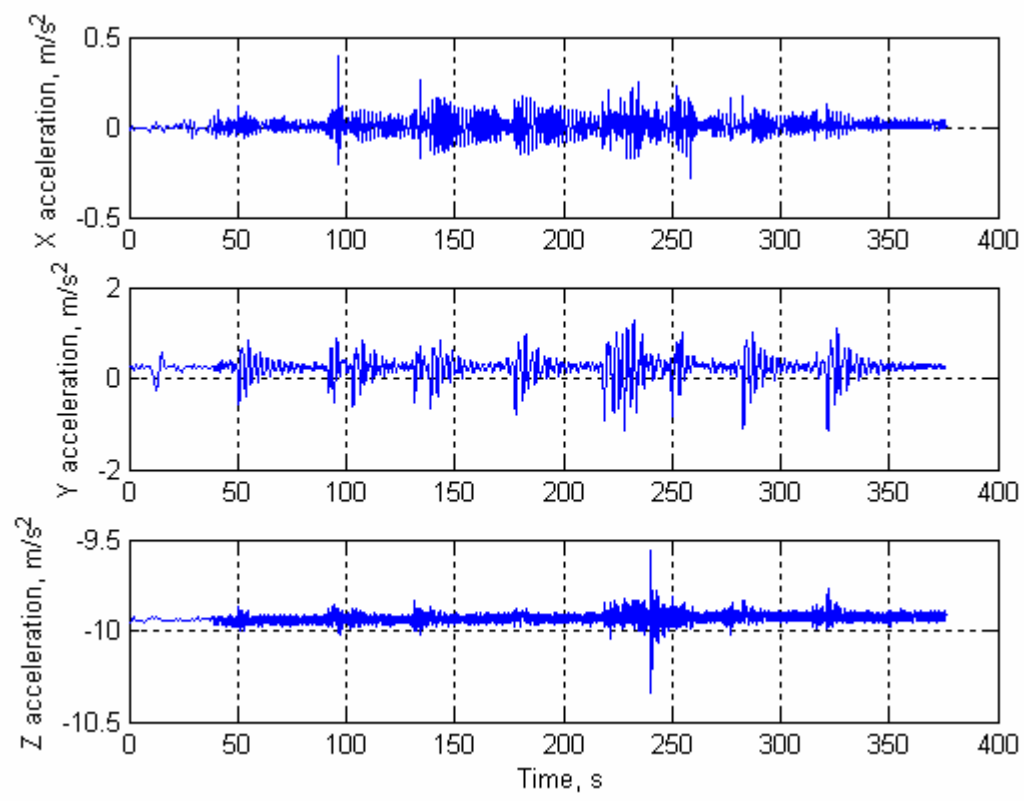
1.1.1 Yaw Swing

Yaw swing data was taken with the following configuration:

- Suspension length = 38.5"
- Horizontal spacing = 23"
- Mass = 10552.4g

Yaw inertia of the aircraft and box was calculated to be $3.15 \pm .05$ slug-ft².



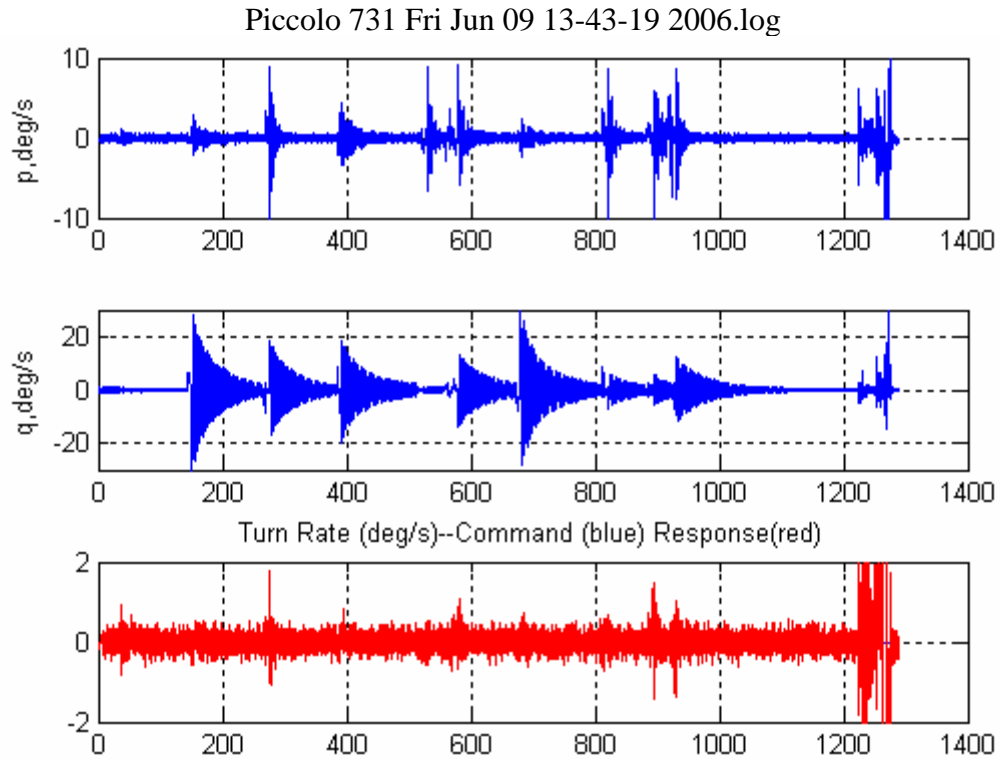


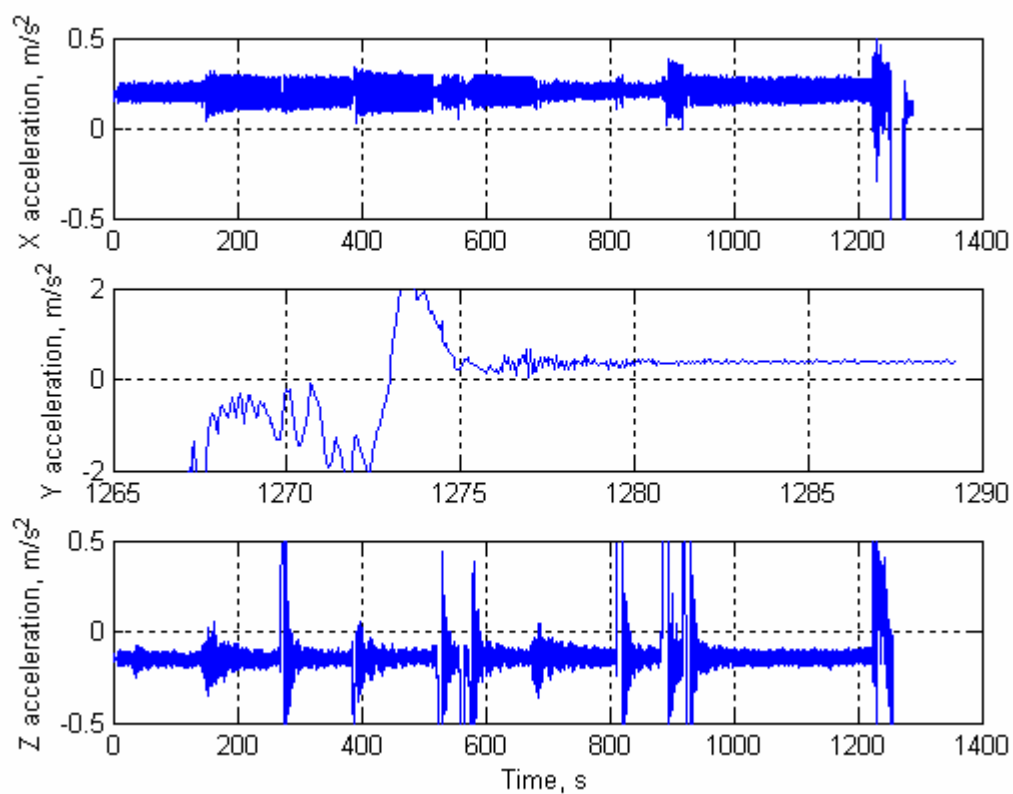
1.1.2 Pitch Swing

Pitch swing data was taken with the following configuration:

- Suspension length = 98.5"
- Horizontal spacing = 23.0"
- Mass = 10552.4g

Pitch inertia of the aircraft and box was found to be $1.21 \pm .01$ slug-ft²





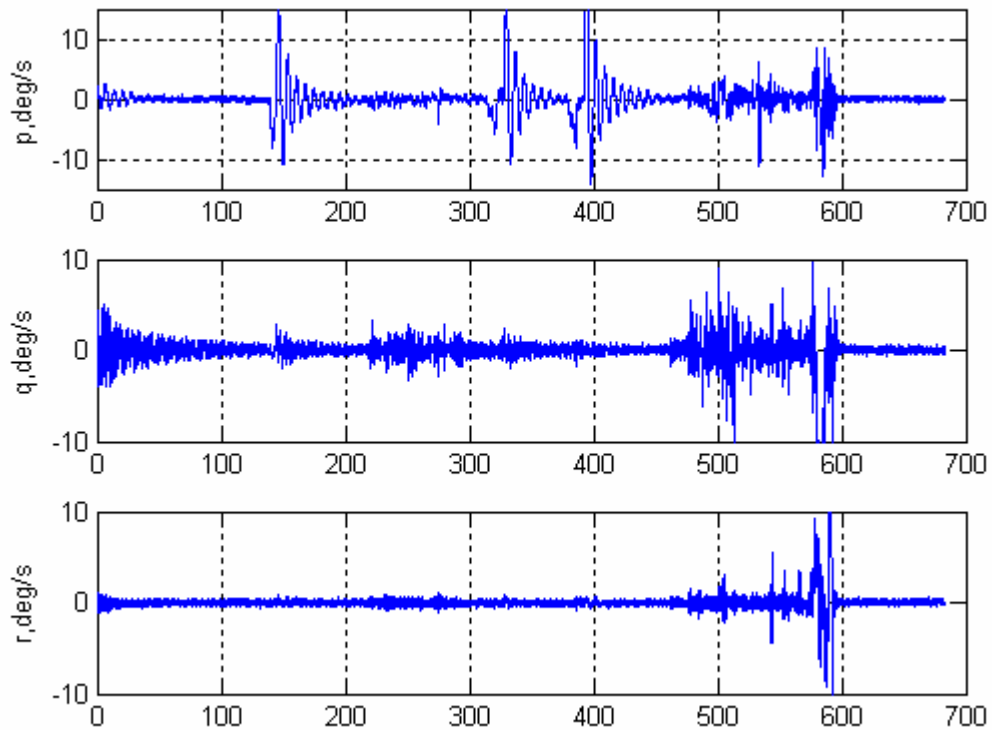
1.1.3 Roll Swing

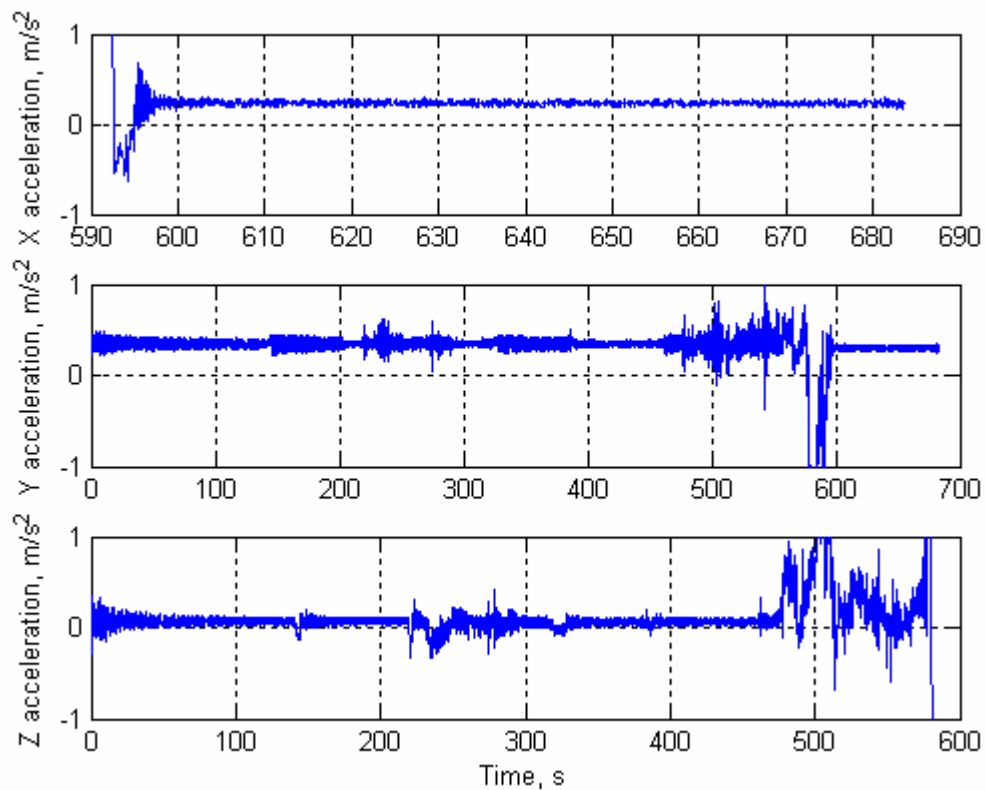
Roll swing data was taken with the following configuration:

- Suspension length = 38.5"
- Horizontal spacing = 11.665"
- Mass = 10552.4g

Roll inertia of the aircraft and box was found to be $2.055 \pm .045$ slug-ft²

Piccolo 731 Mon Jun 05 10-32-59 2006.log





1.1.4 Calculated Inertia Values

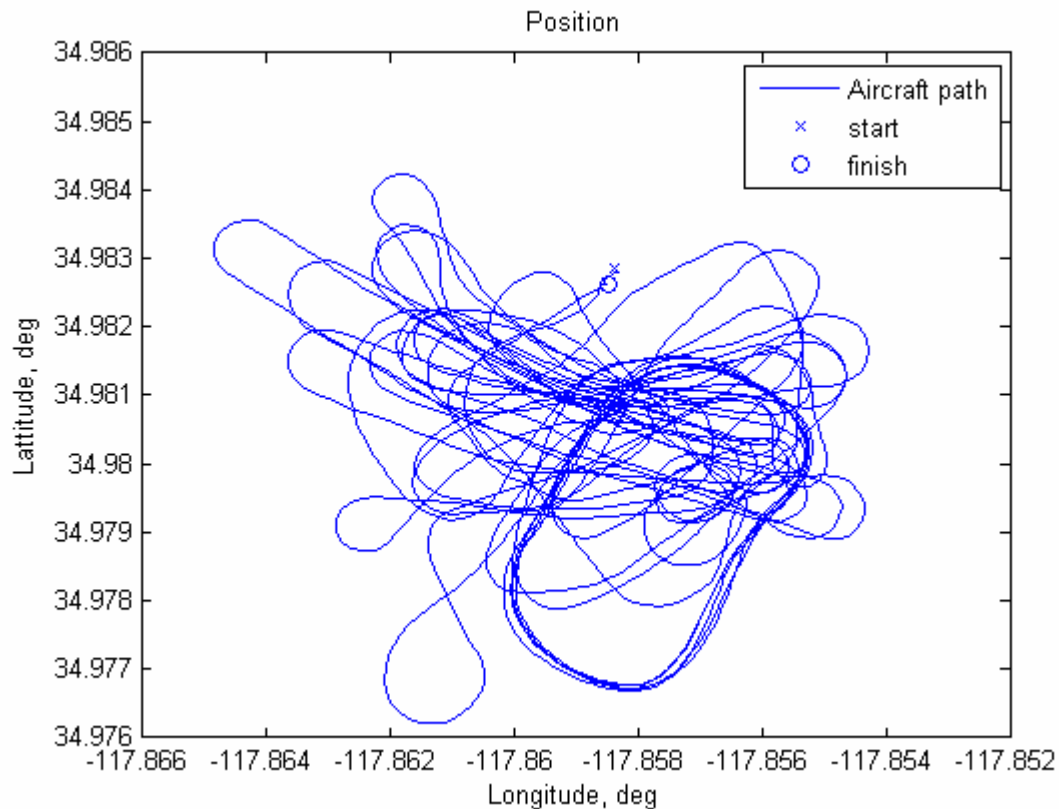
Final inertia values for the SBXC were found to be:

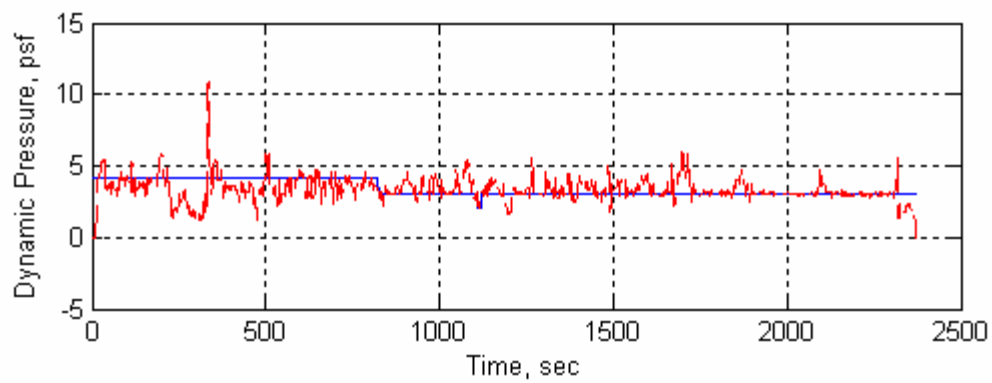
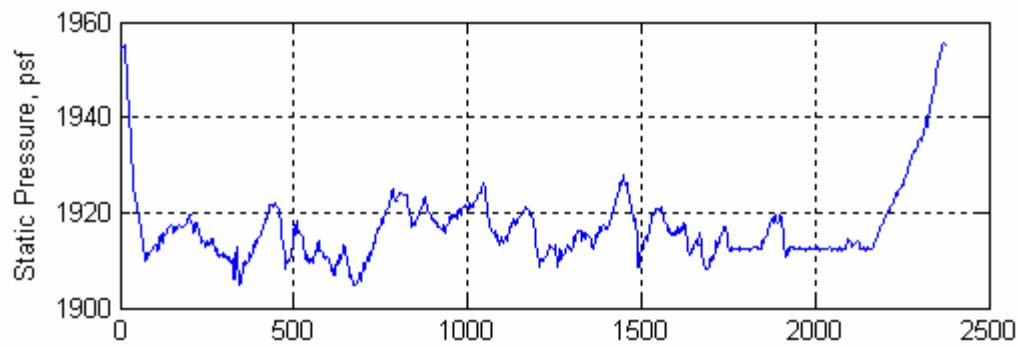
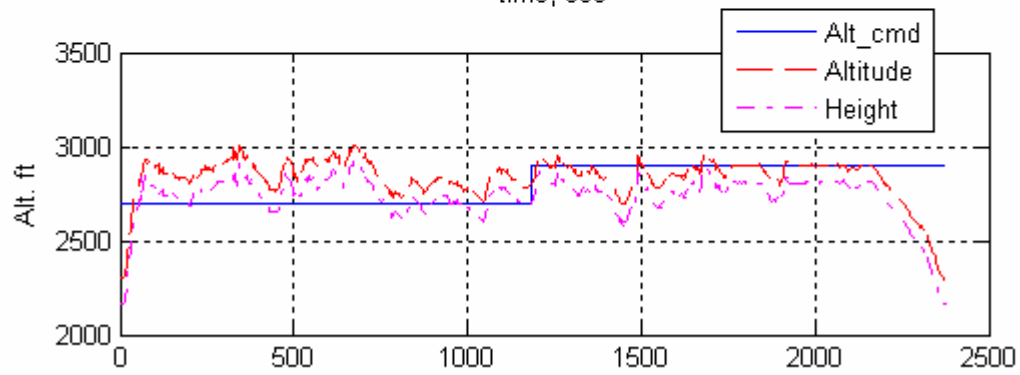
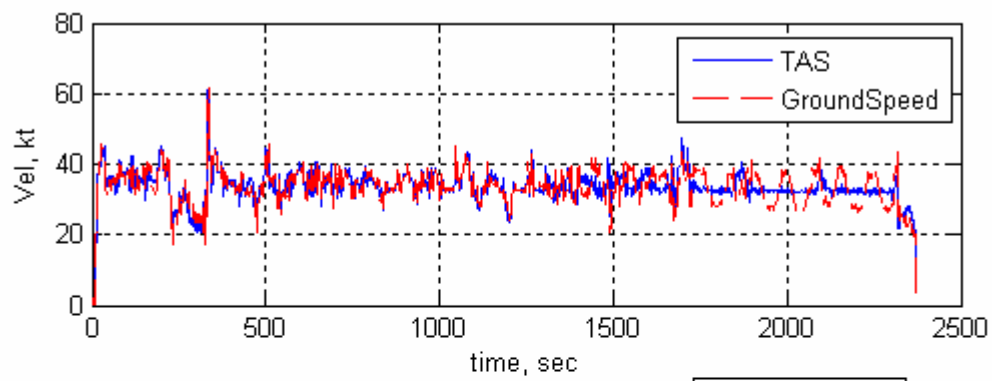
- $I_{xx}=1.978 \text{ slug-ft}^2$
- $I_{yy}=1.064 \text{ slug-ft}^2$
- $I_{zz}=3.001 \text{ slug-ft}^2$
- $I_{xz}=0.089 \text{ slug-ft}^2$
- CG 26.851" aft of nose tip
- CG 0.000" right of center line
- CG 0.829" above horizontal ref line (tip of nose to center of rudder control horn bulge)
- Aircraft mass=0.473 slug

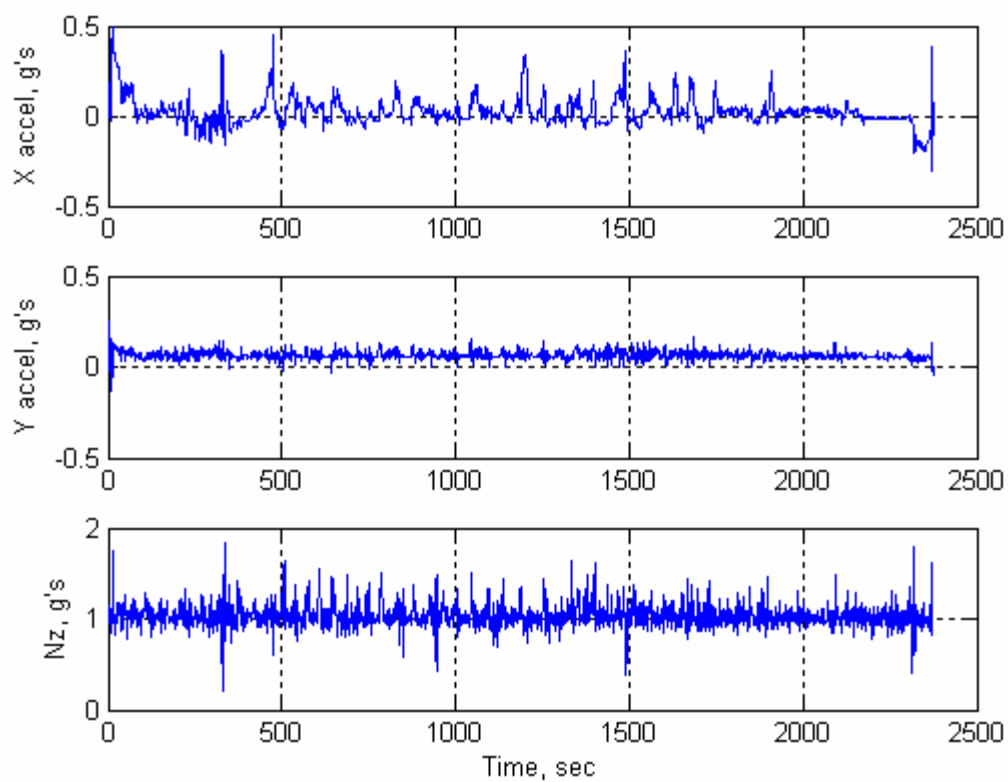
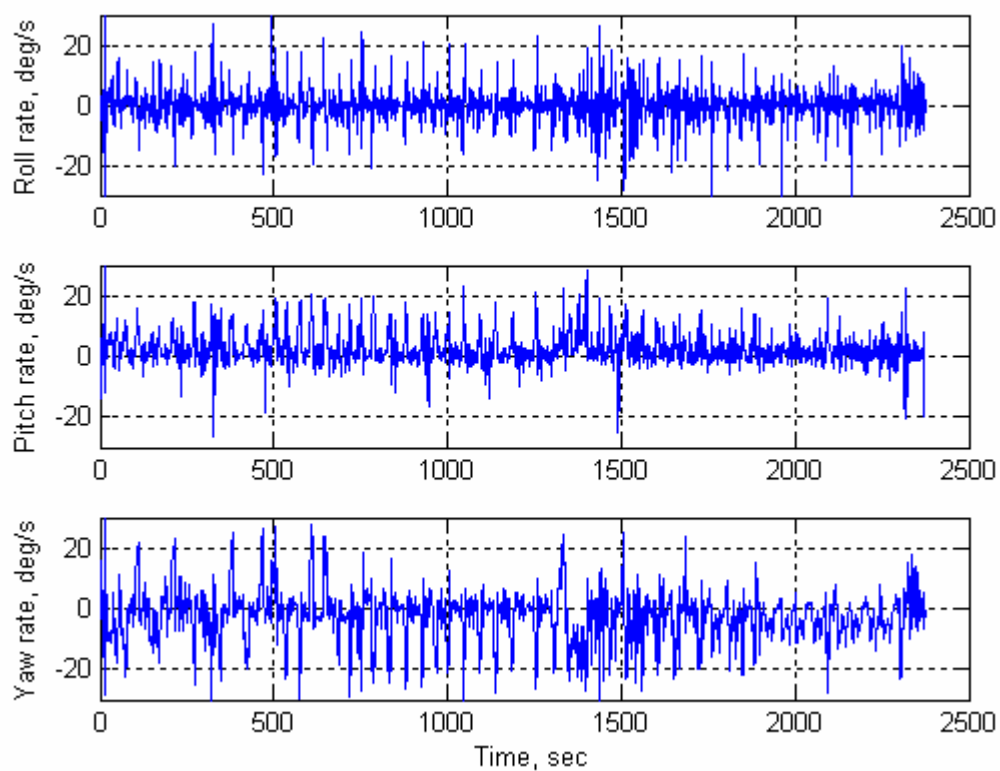
1.2 Cloud Swift 1, Checkout Flight 1

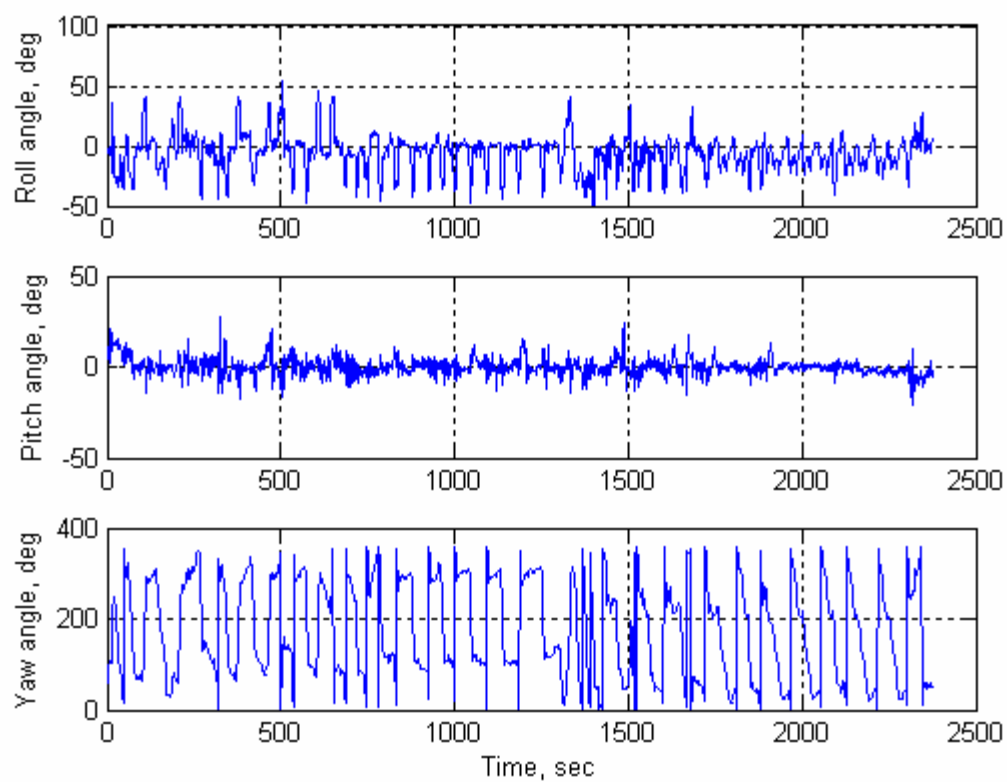
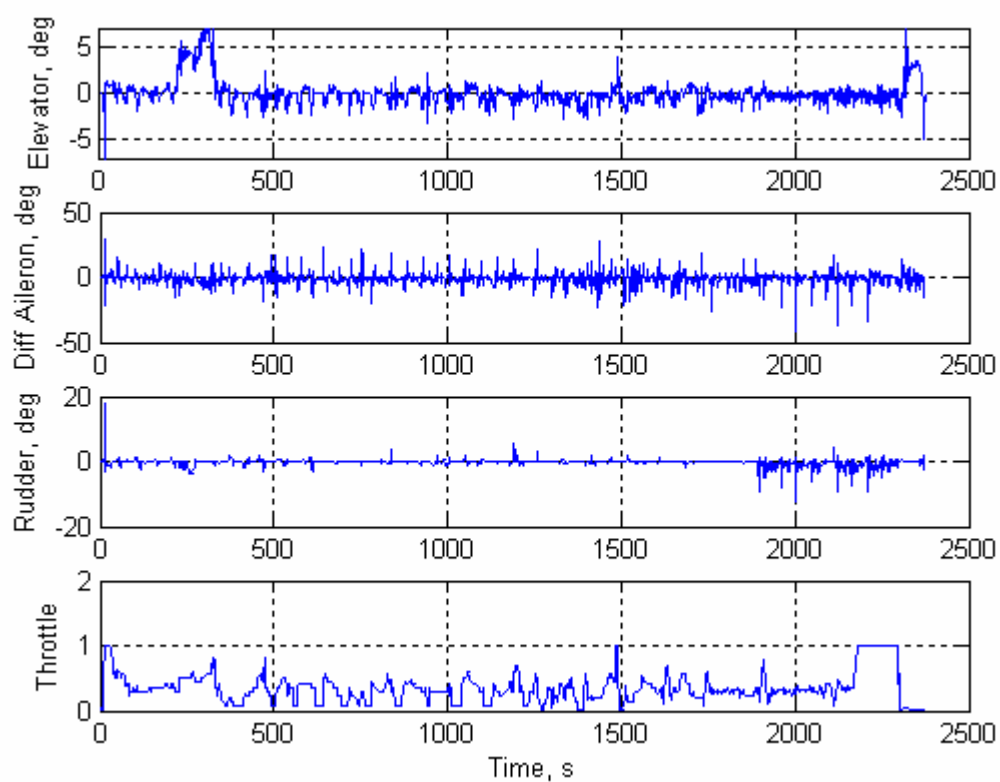
Checkout of new Piccolo software, gps antenna, speed controller, and propeller, using the Cloud Swift-1 airframe was performed in June of 2006. A piccolo-2 autopilot with version 1.3.1 software was used along with a geo-helix gps antenna, 90A hacker speed controller, and 17x10 prop. The doublet feature of the software was tested in all axes. Doublet file data is displayed here along with Piccolo telemetry data for the entire flight.

Checkout flight 1 was performed on June 28. Filename= ds_checkoutflt01.mat



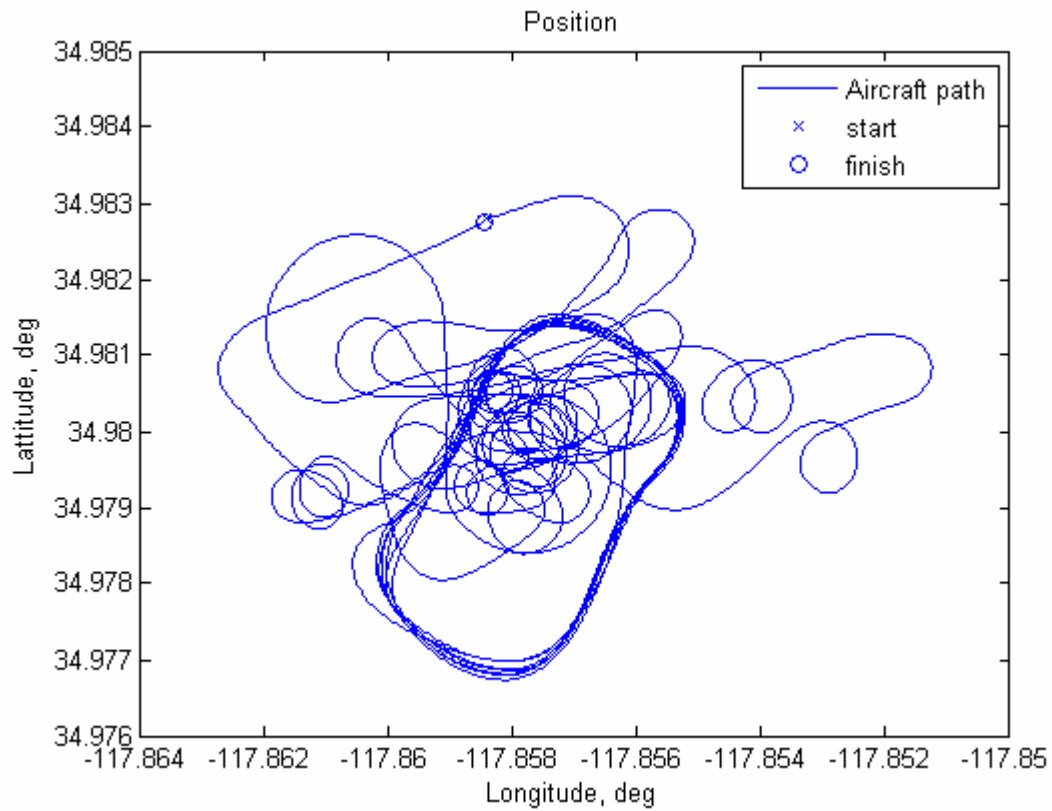


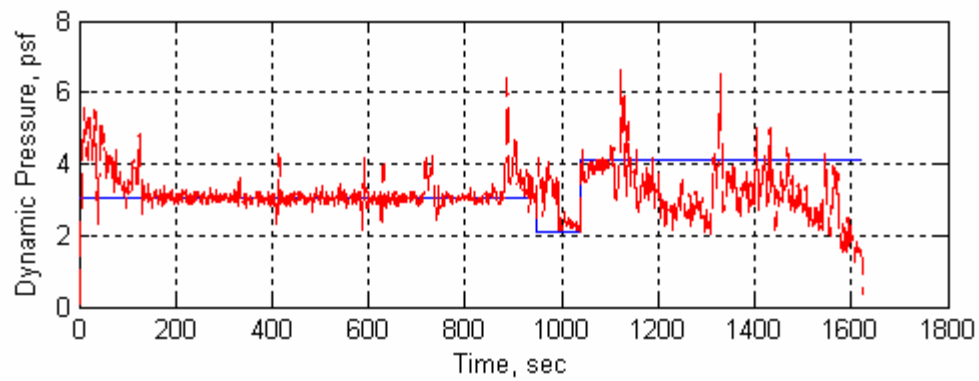
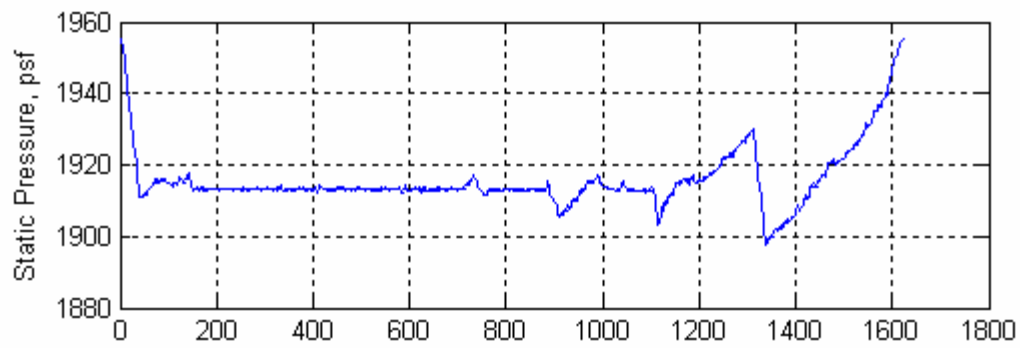
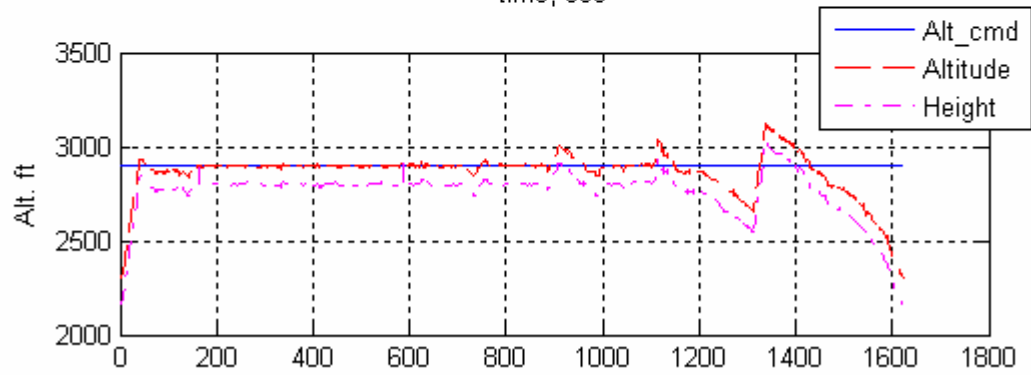
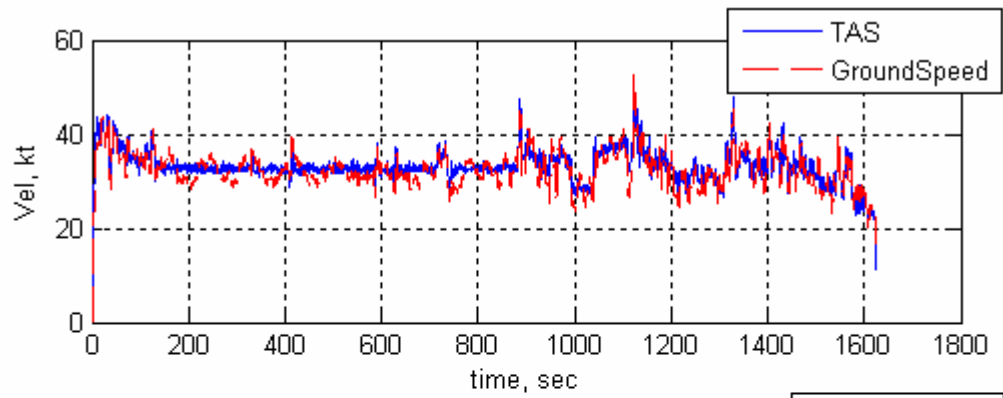


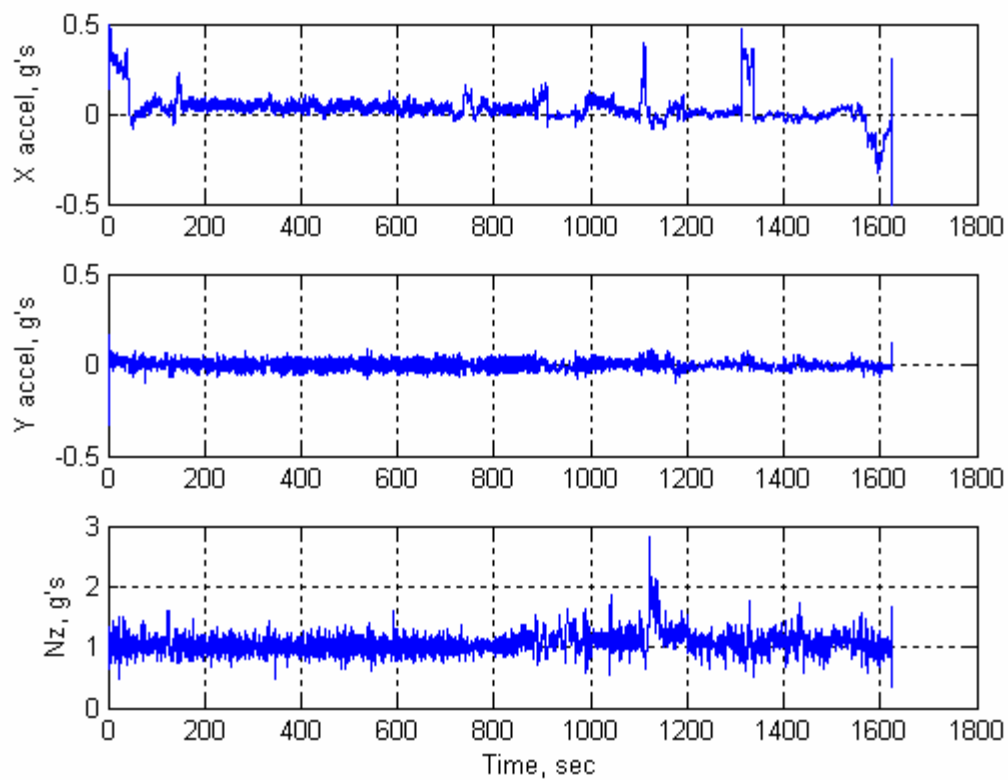
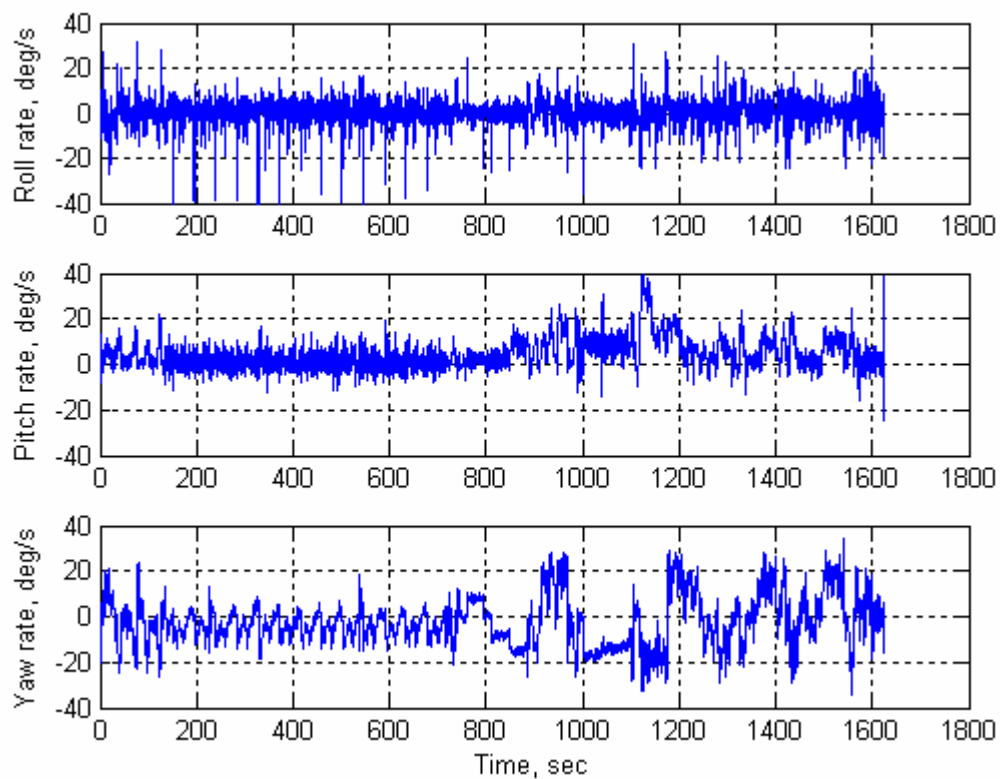


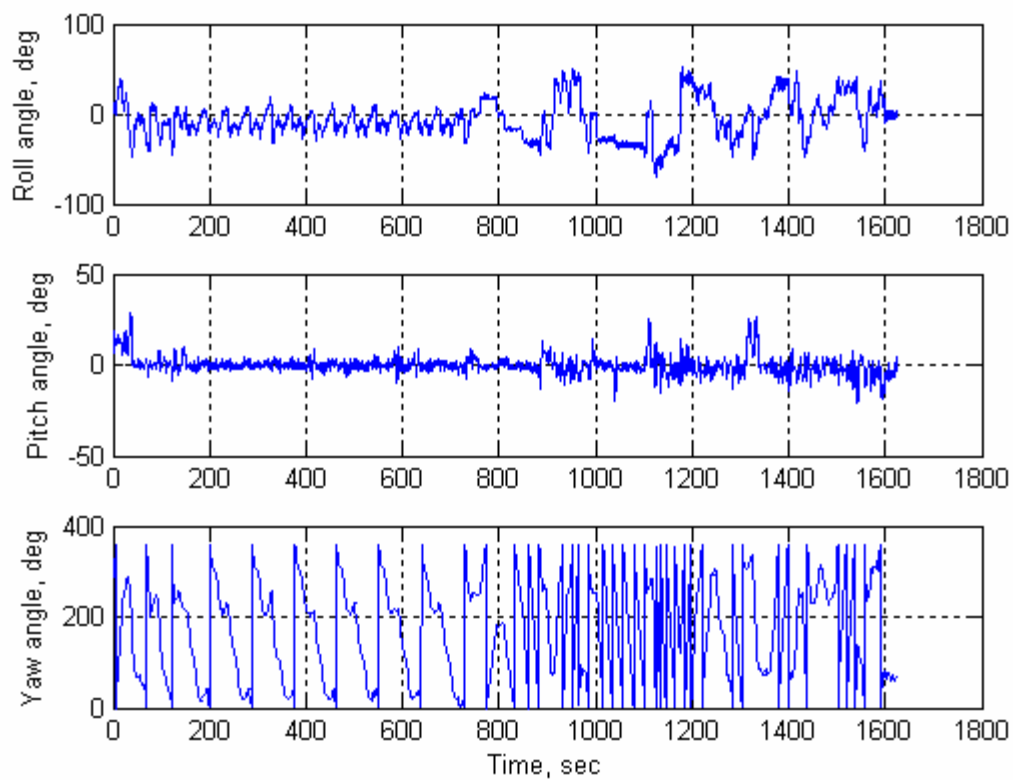
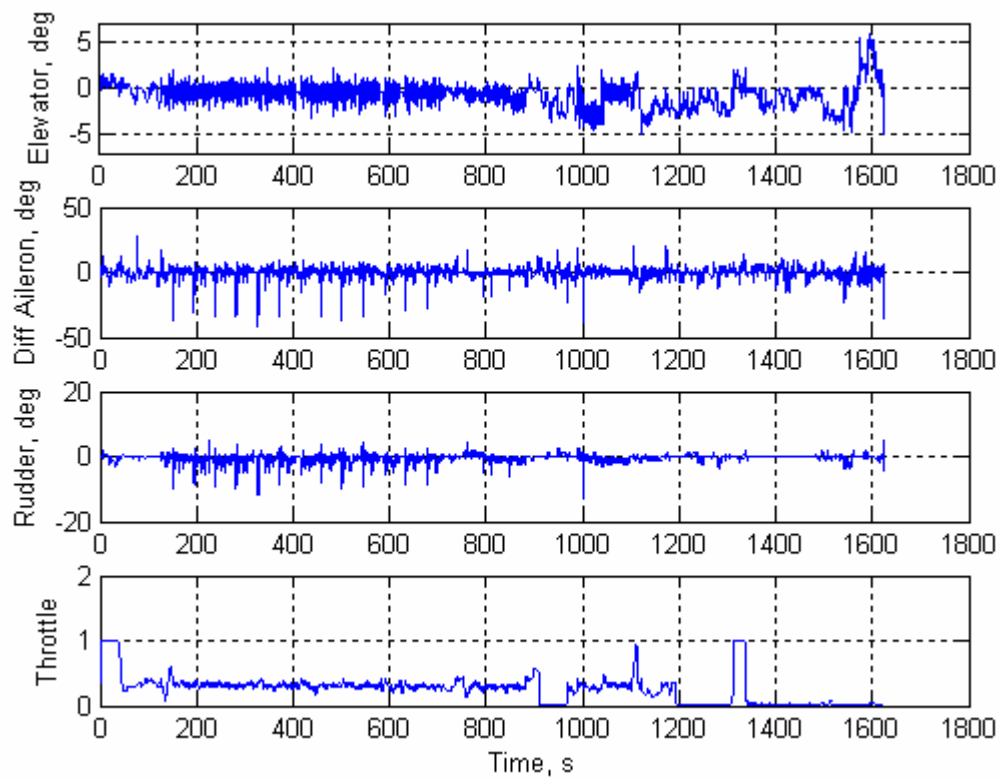
1.3 *Cloud Swift 1, Checkout Flight 2*

Checkout flight 2 was also performed on June 28, 2006. Filename=ds_checkoutflt02.mat

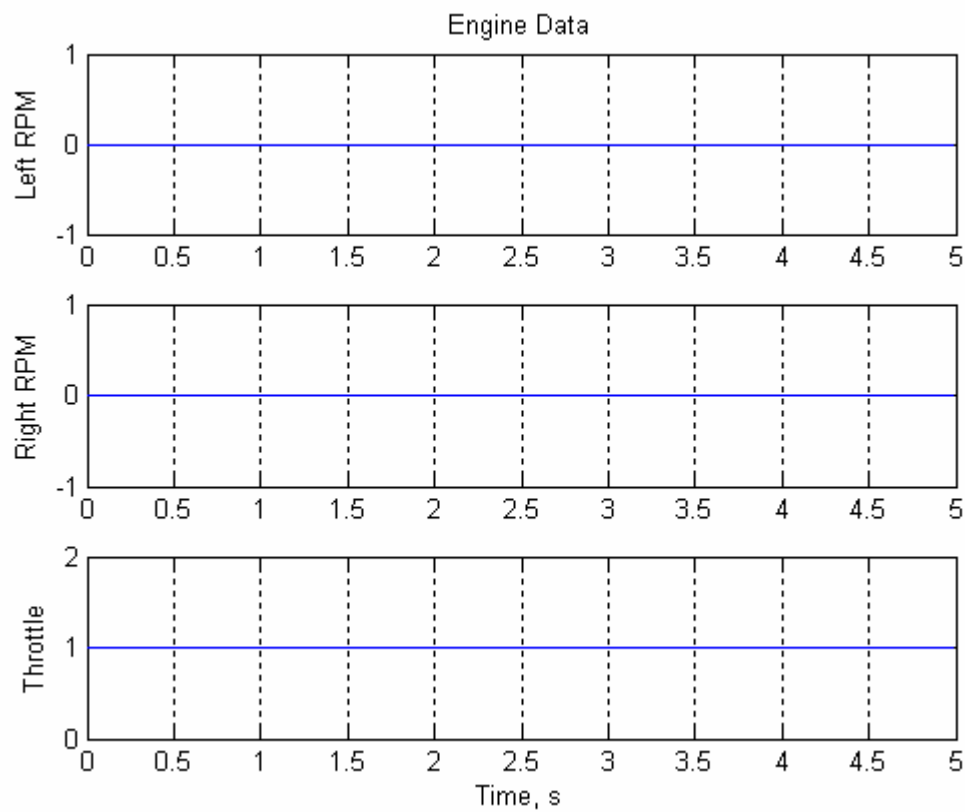
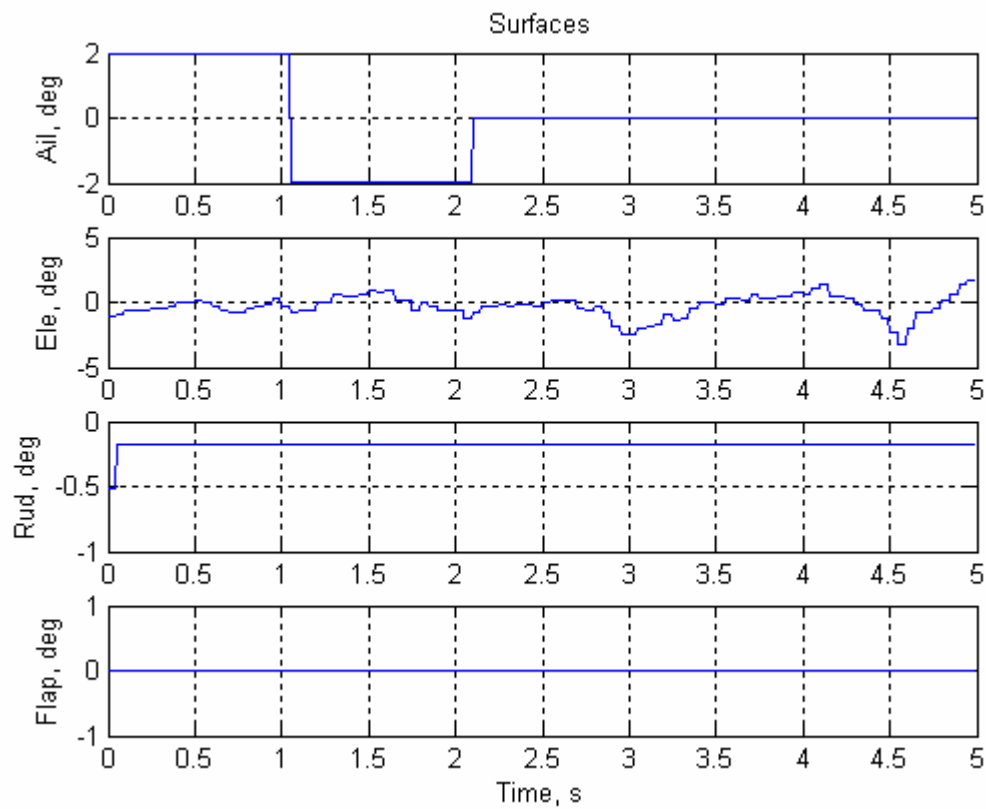


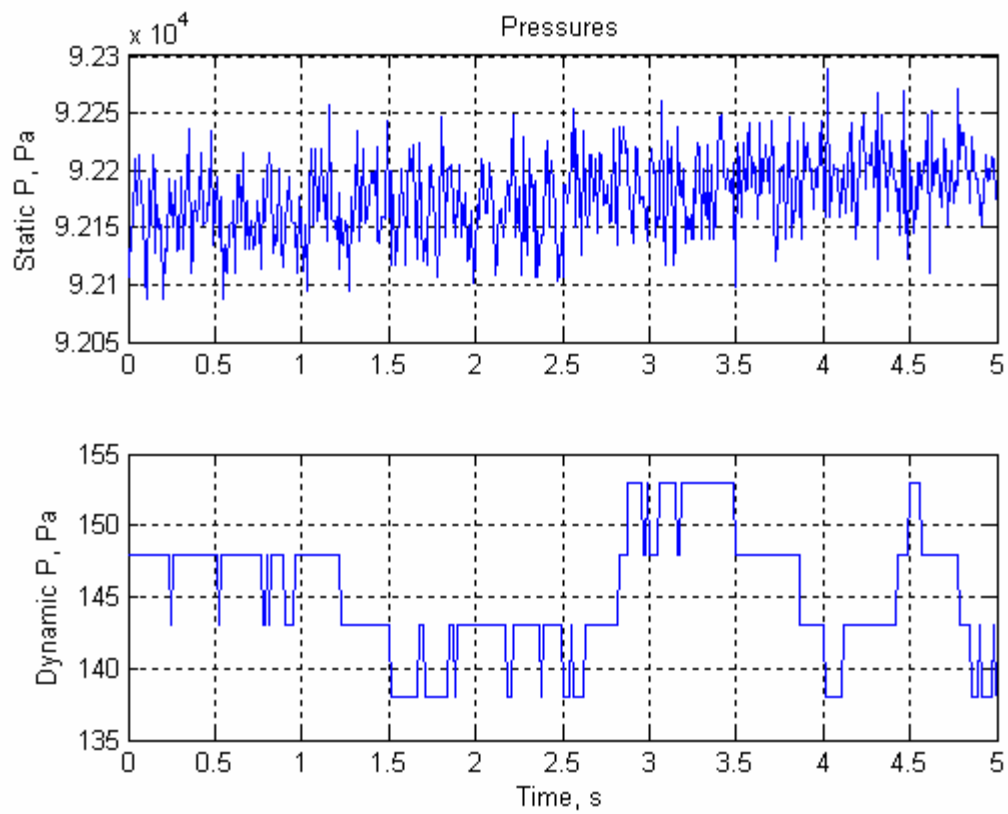
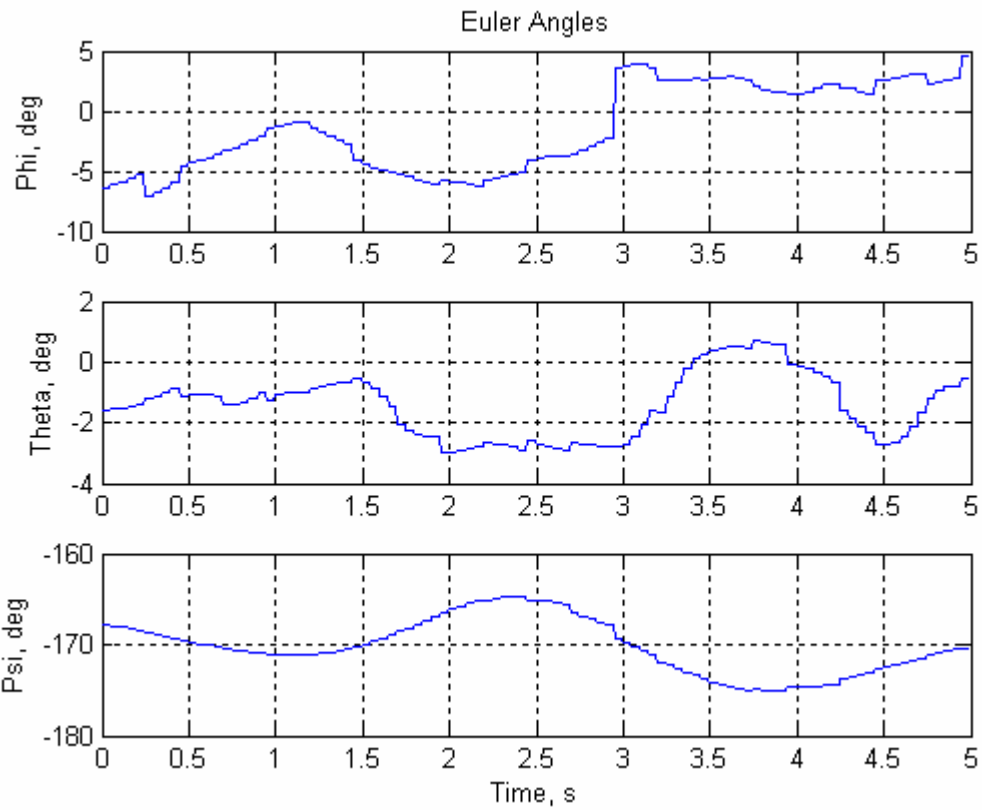


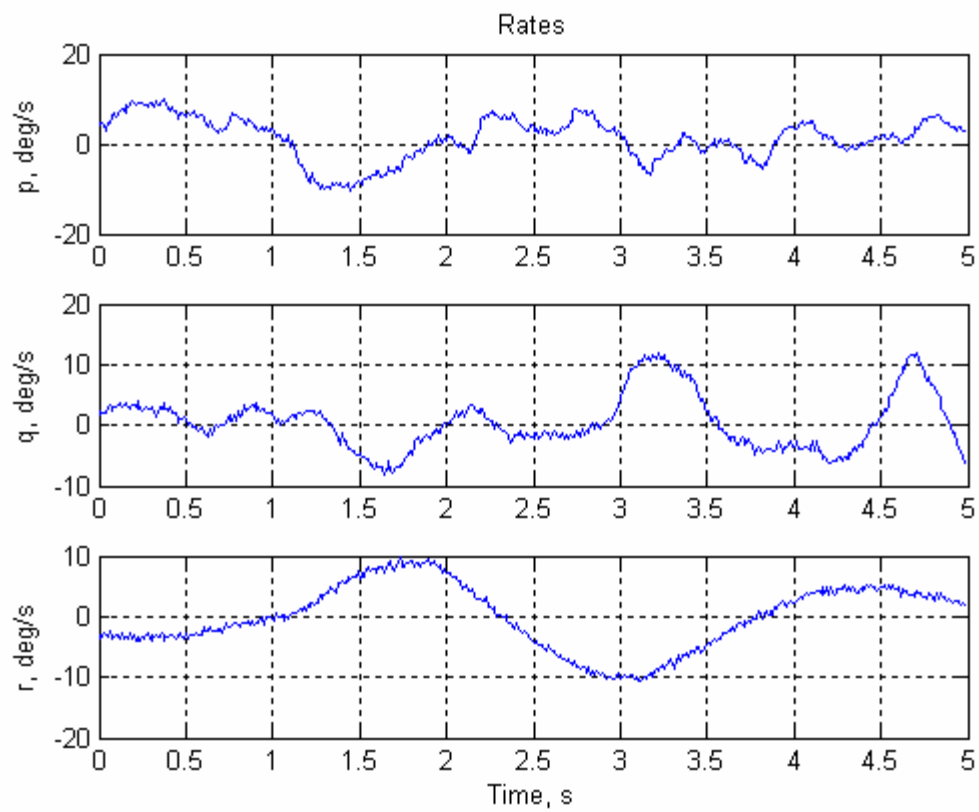
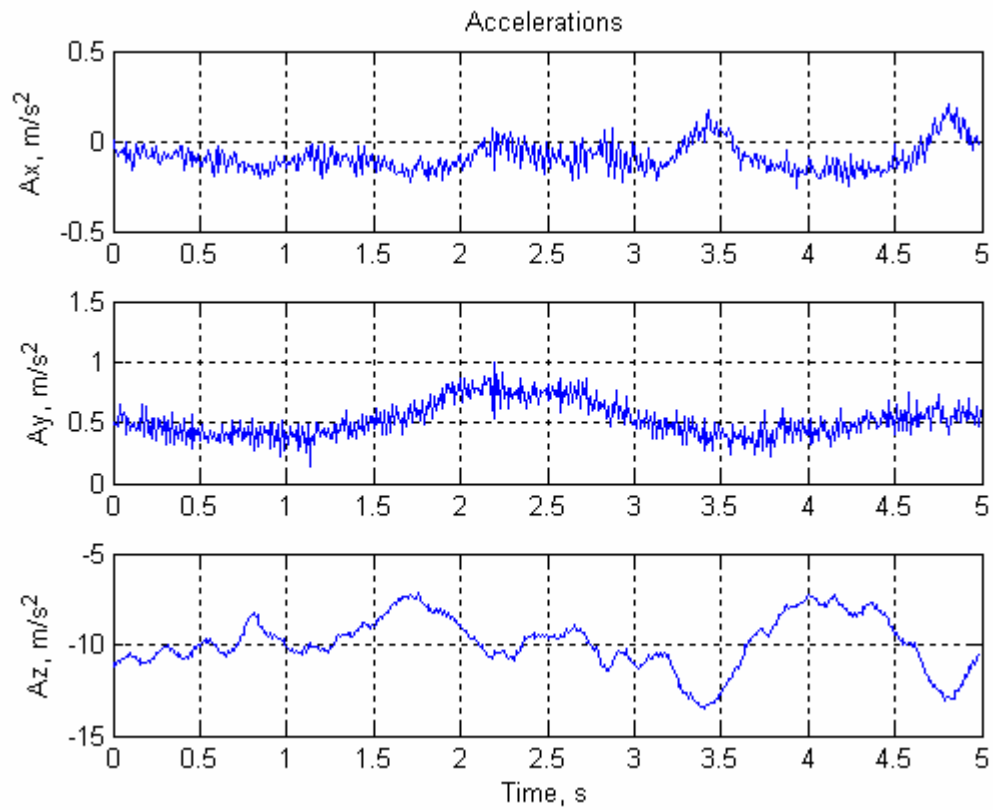




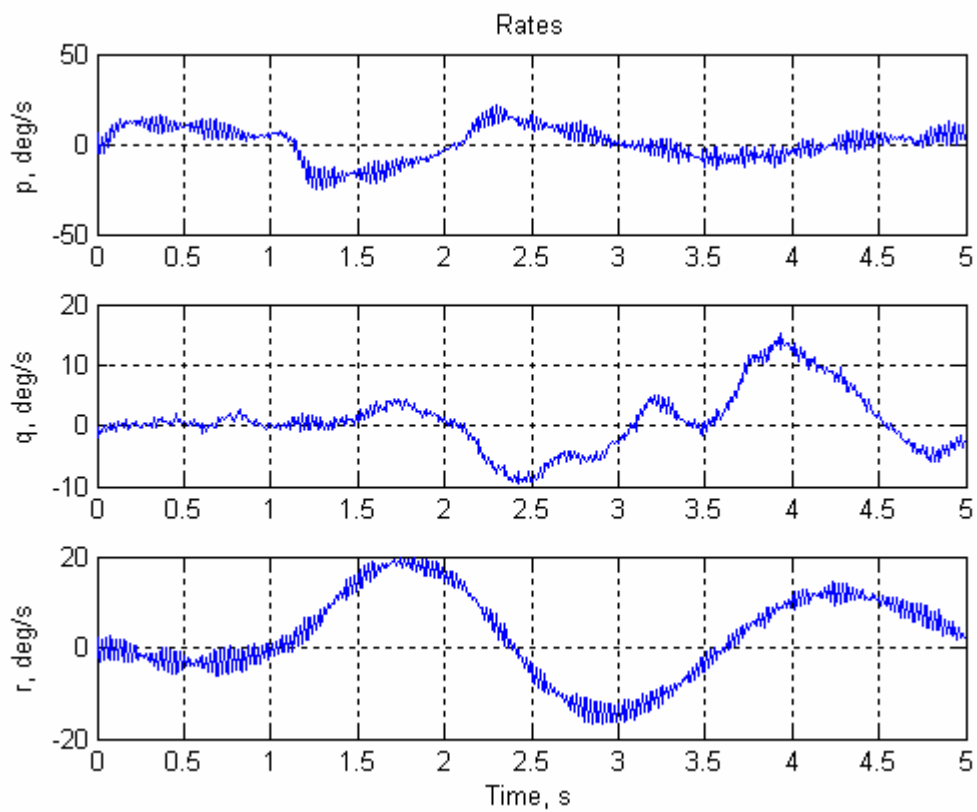
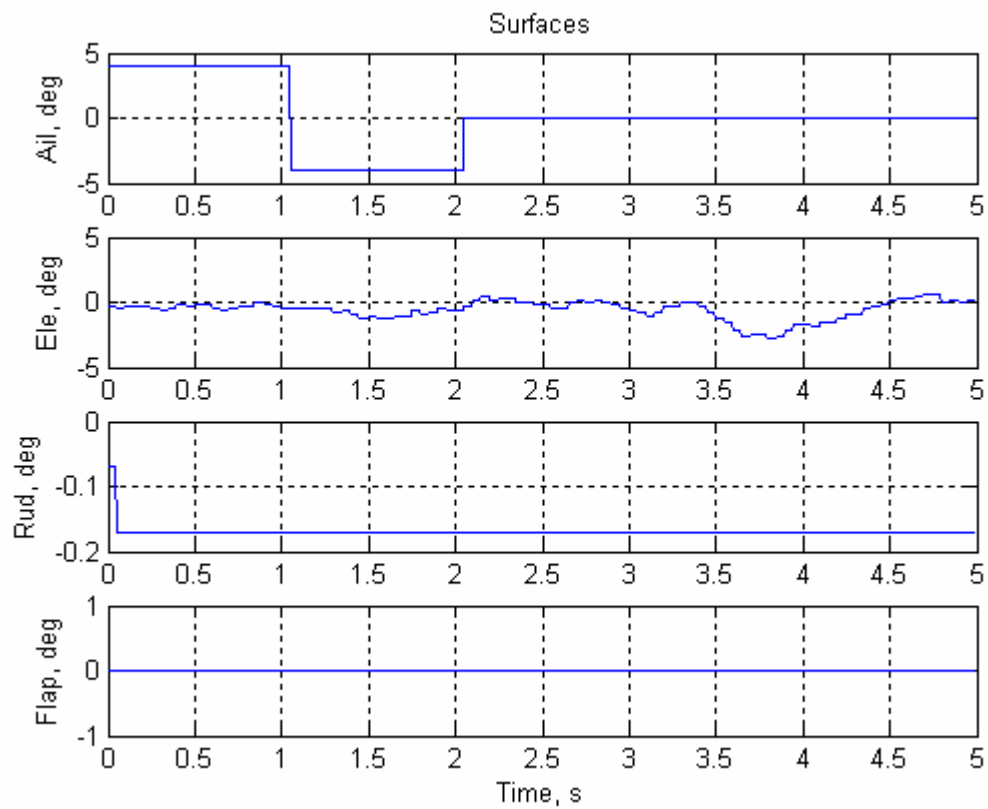
1.3.1 Aileron Doublet 1

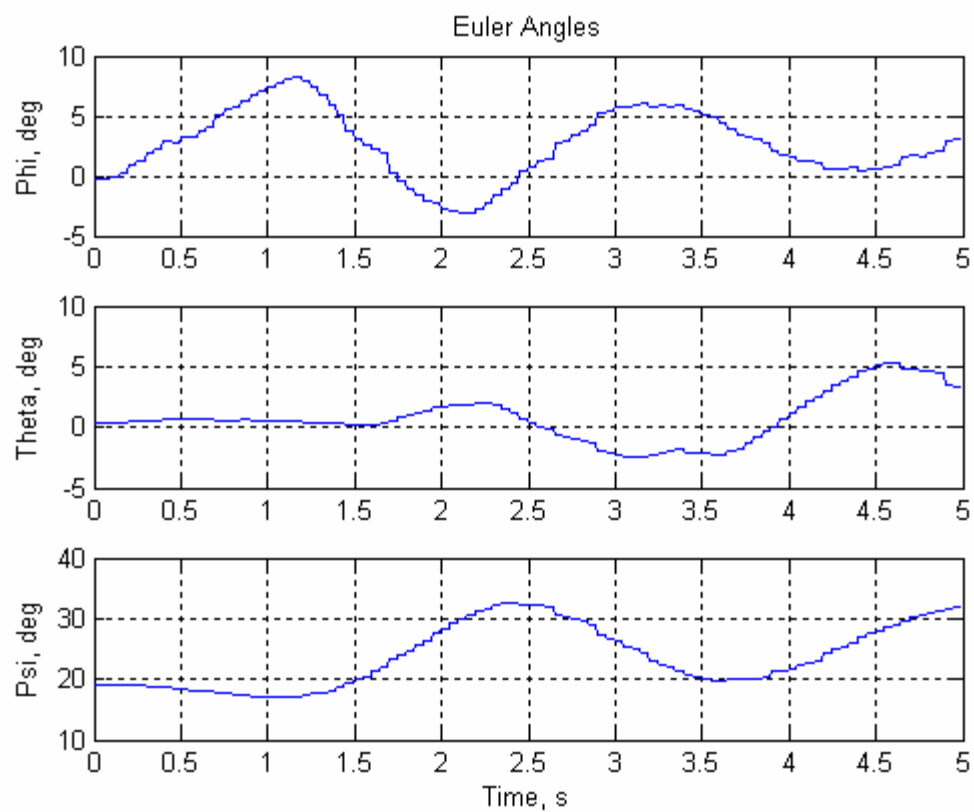
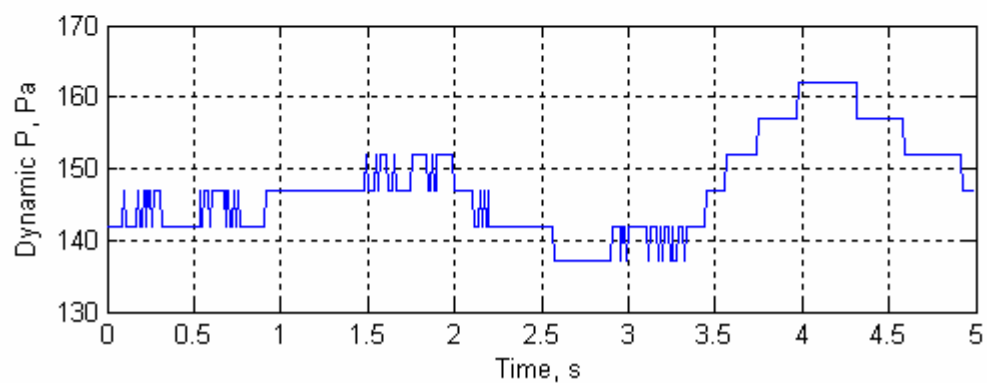
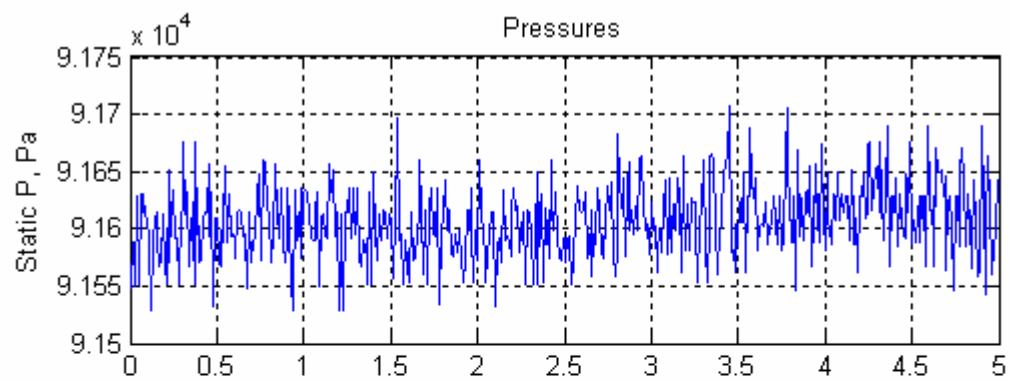


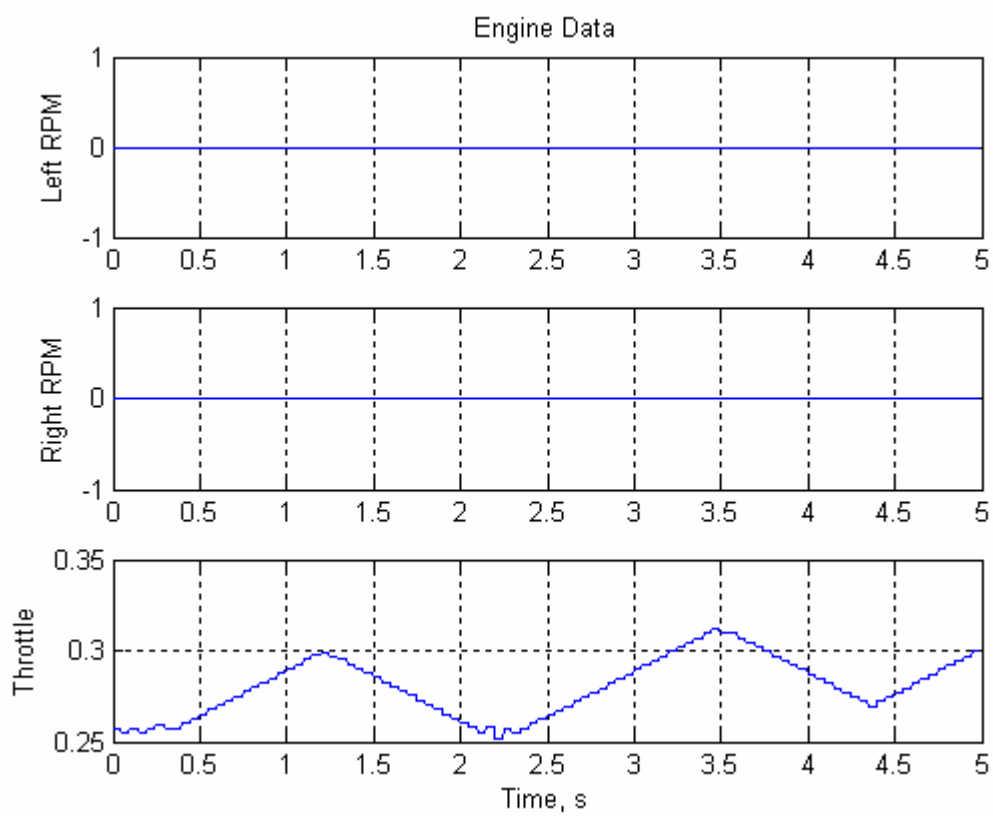




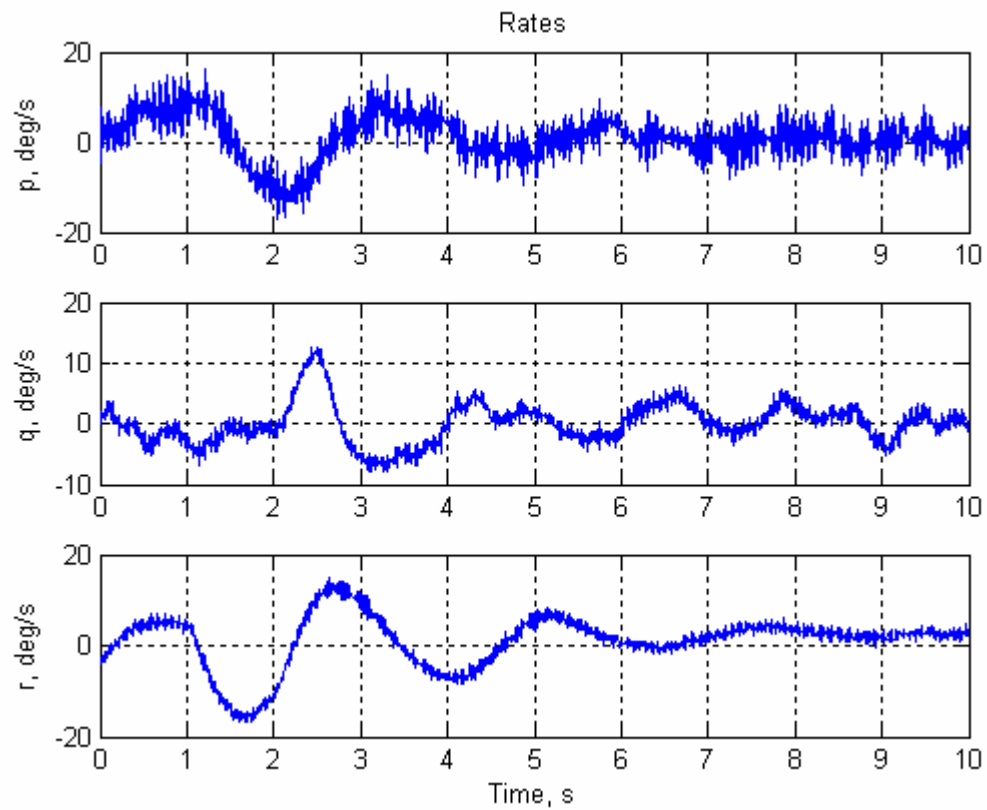
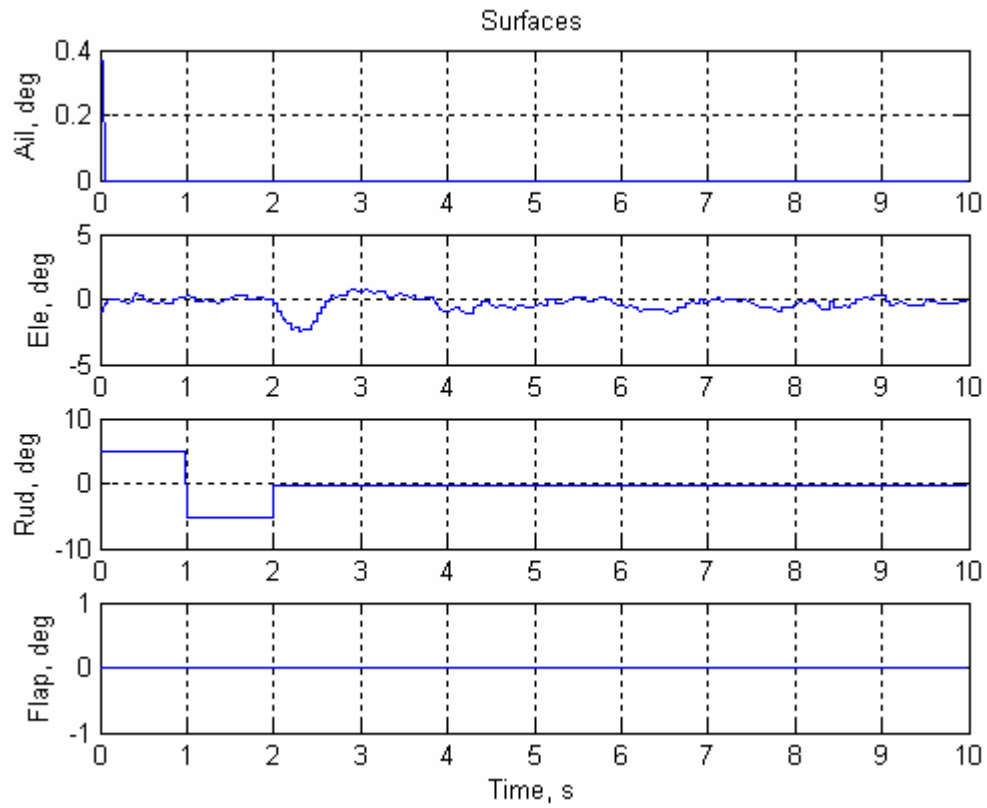
1.3.2 Aileron Doublet 2

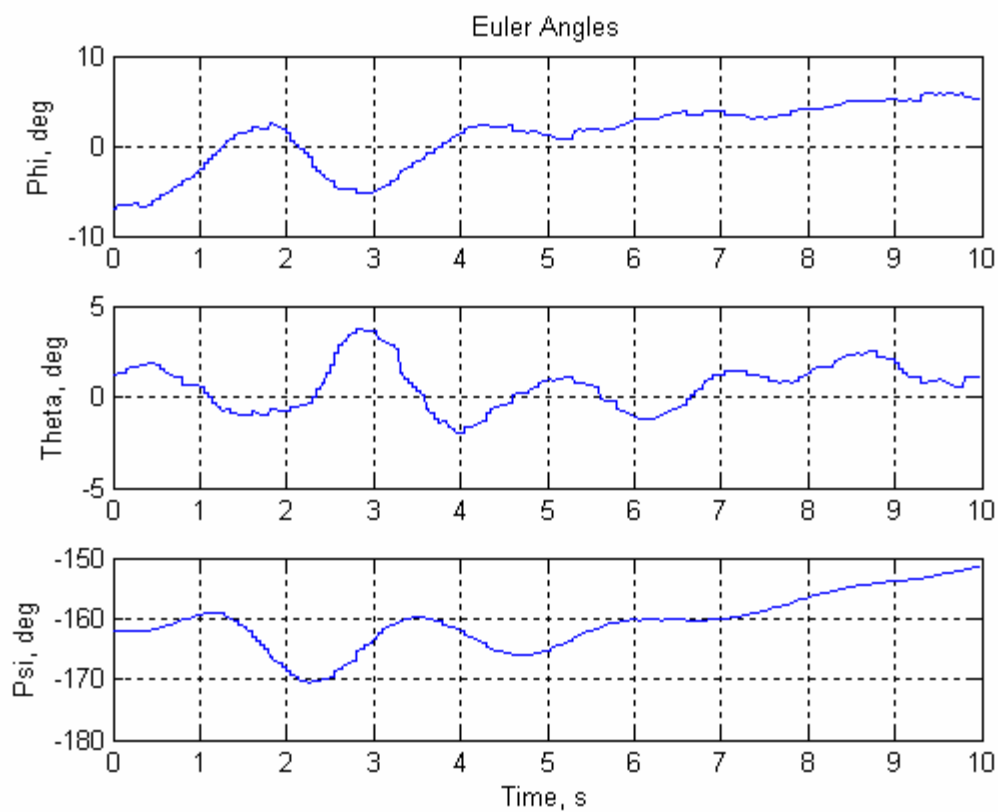
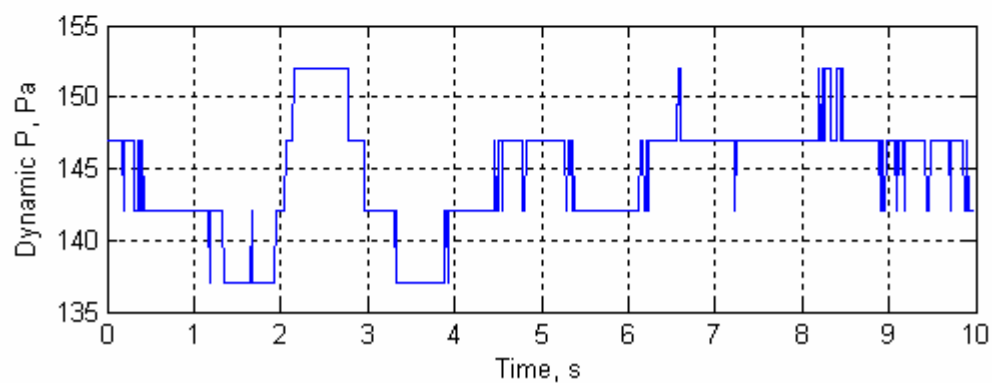
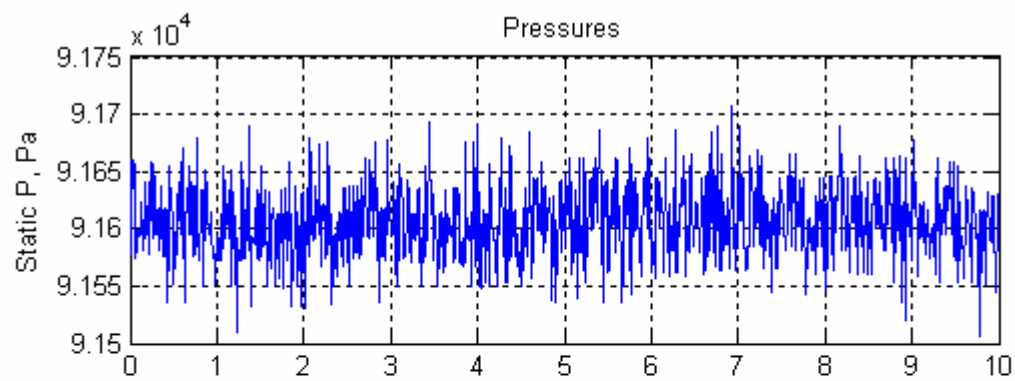


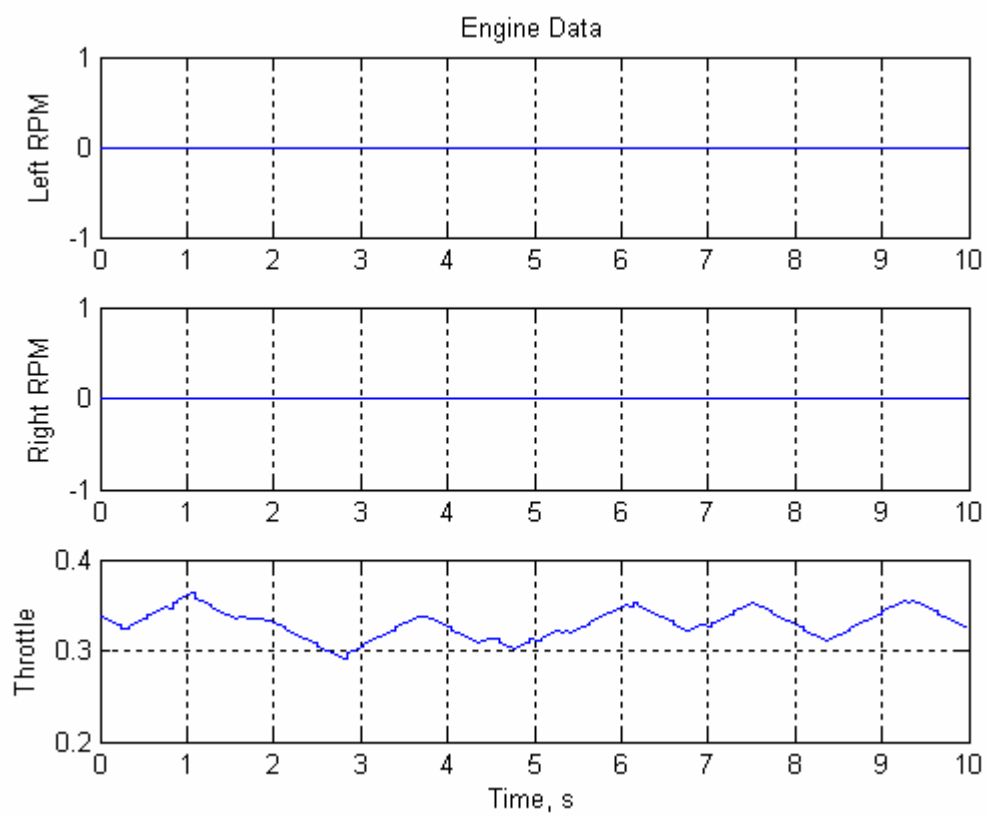




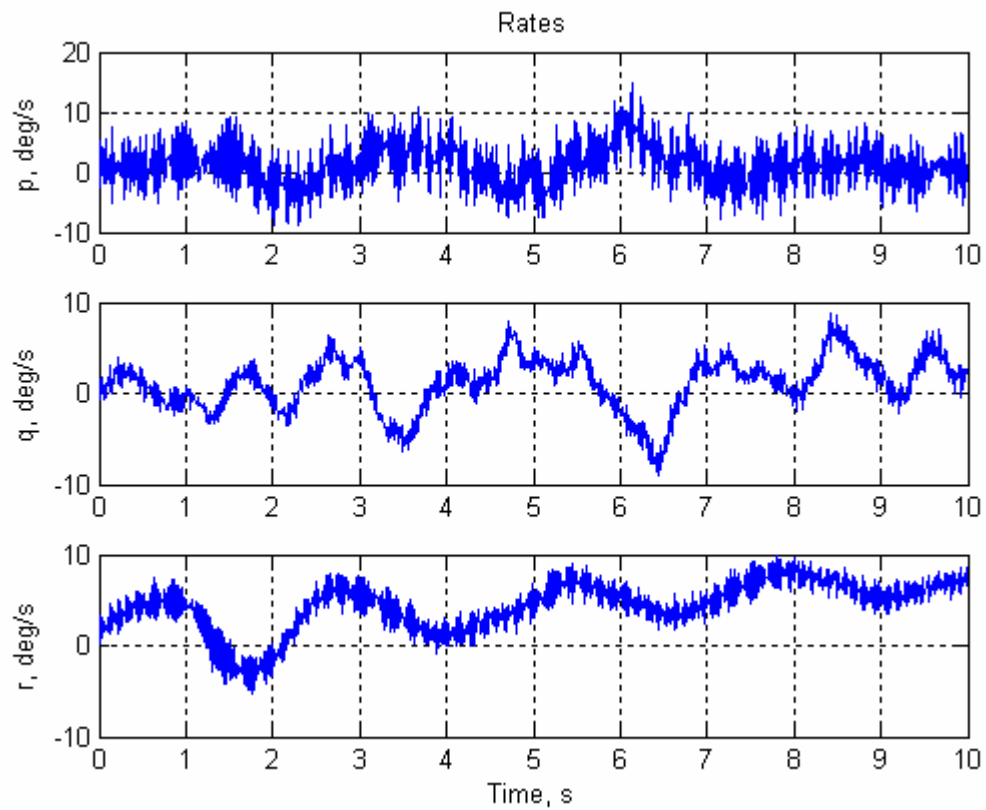
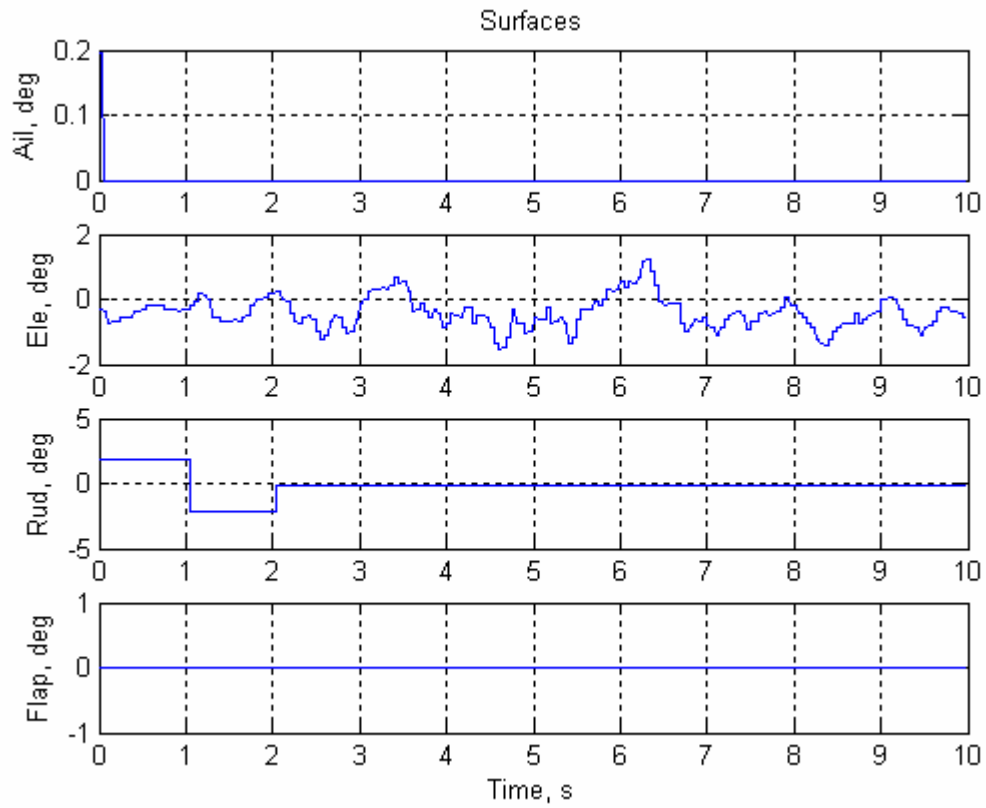
1.3.3 Rudder Doublet 1

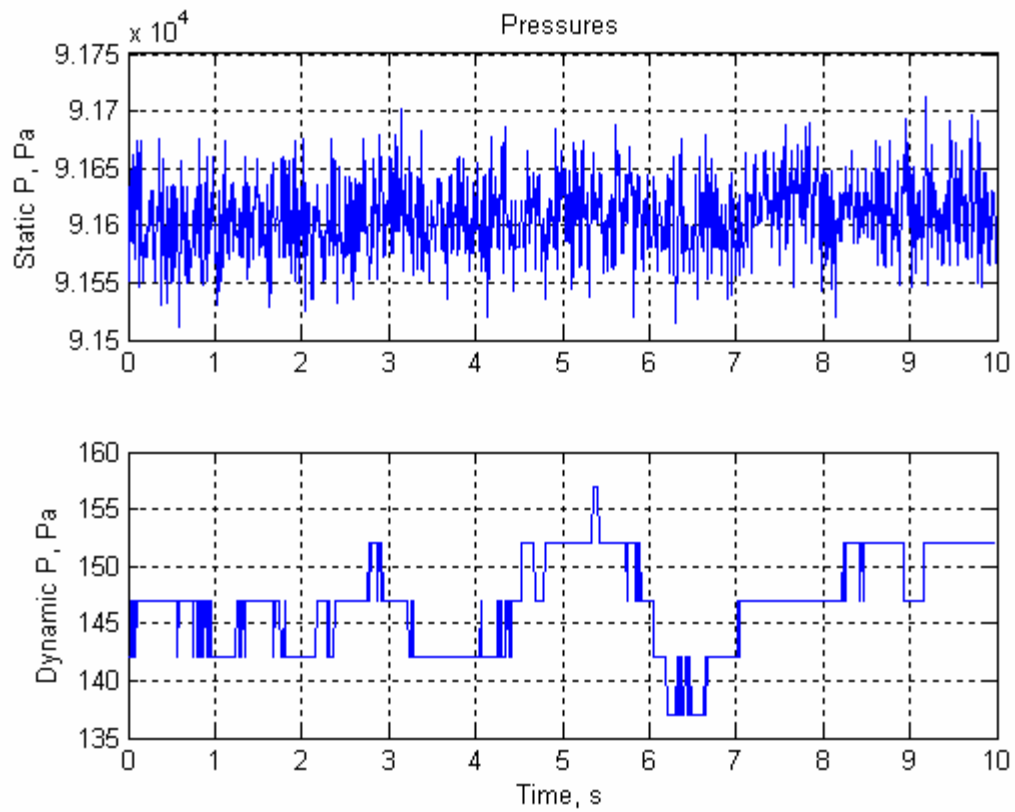
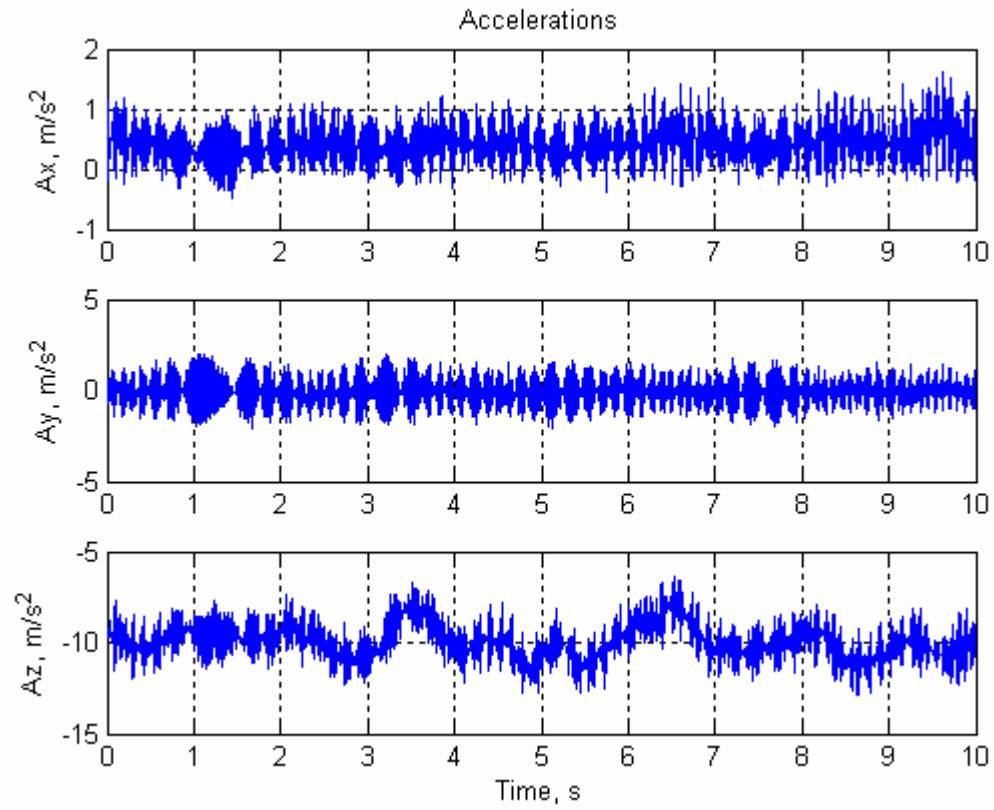


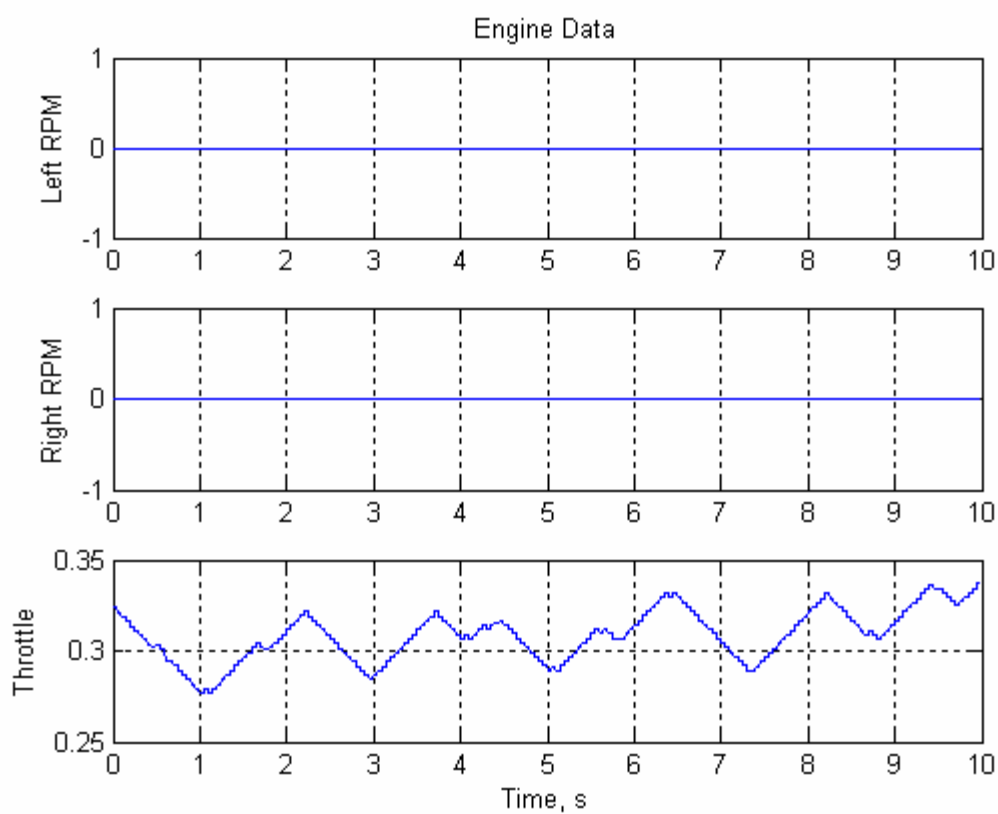
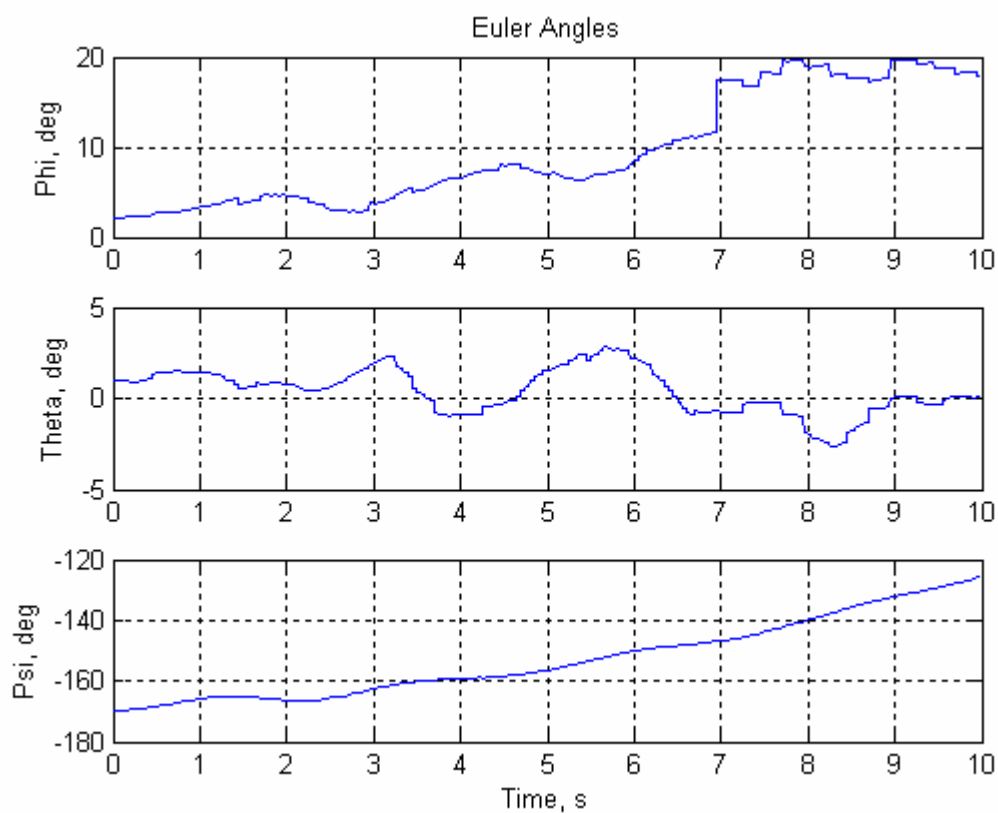




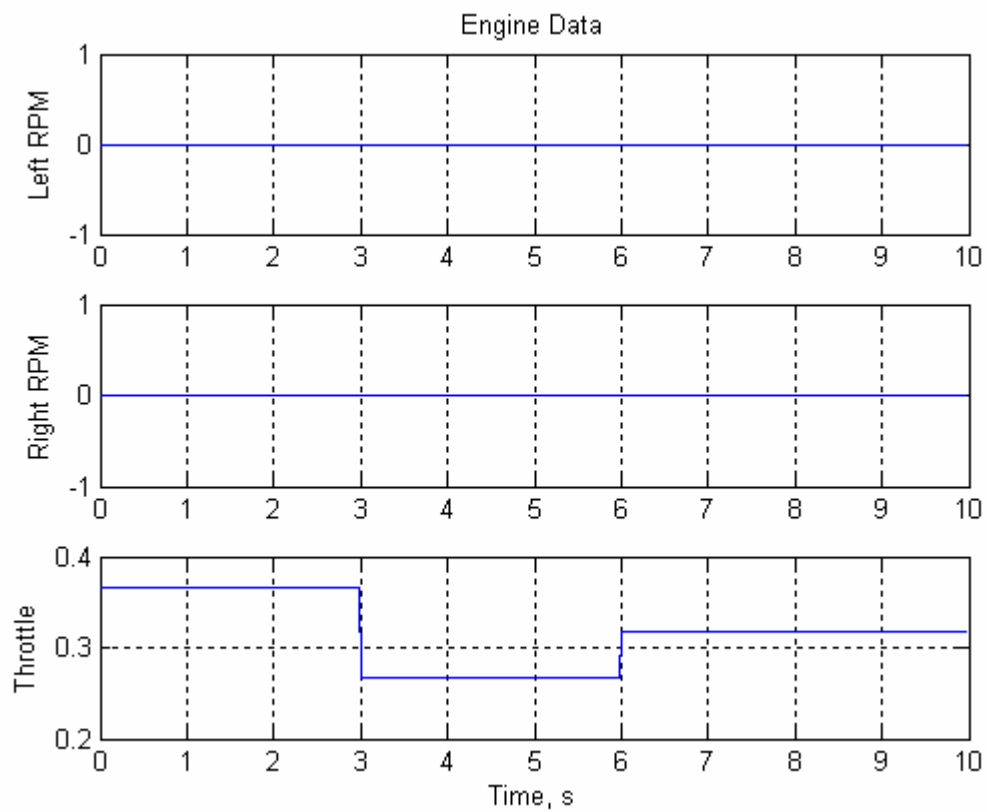
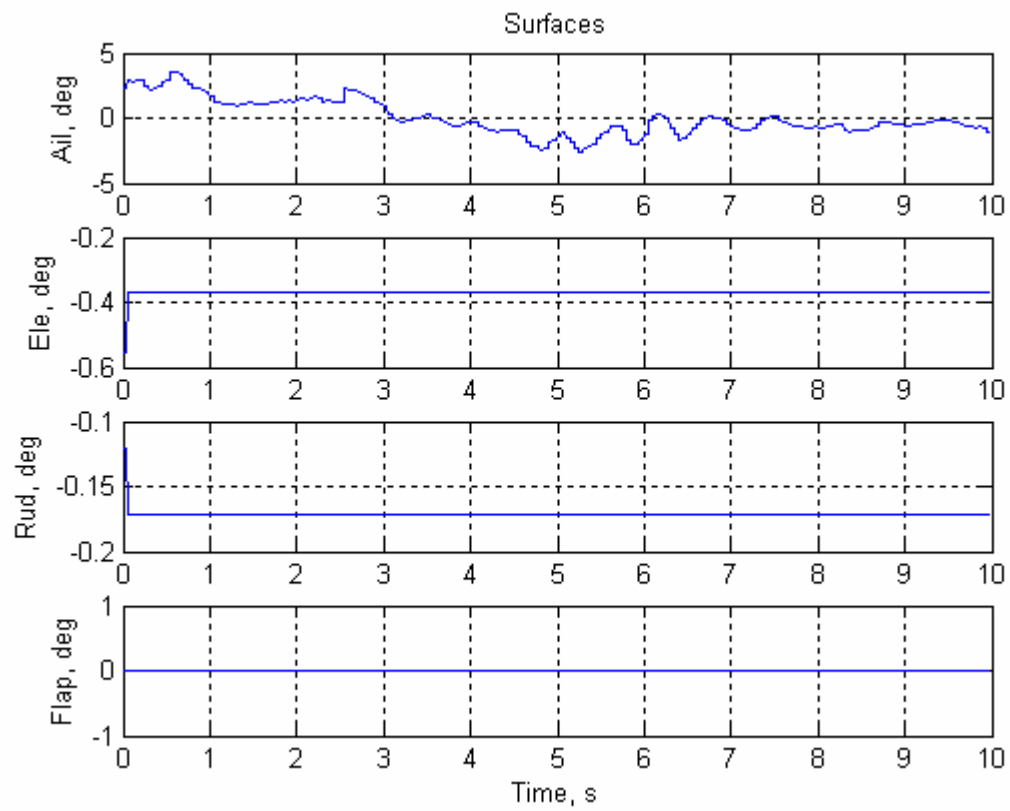
1.3.4 Rudder Doublet 2

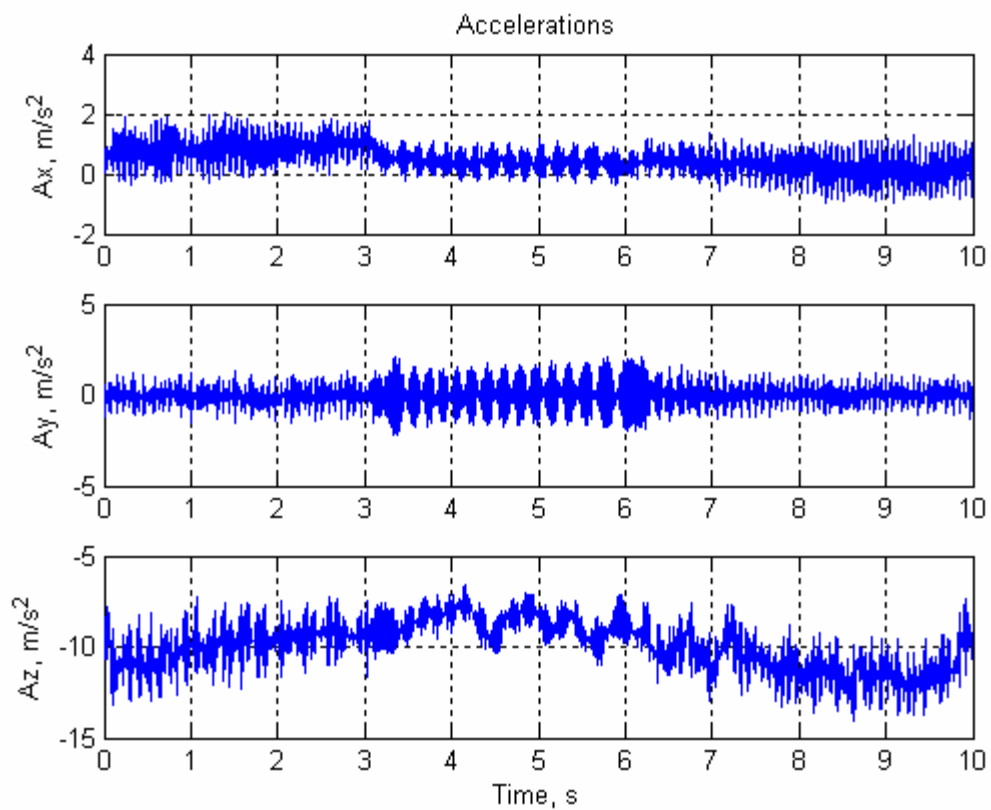
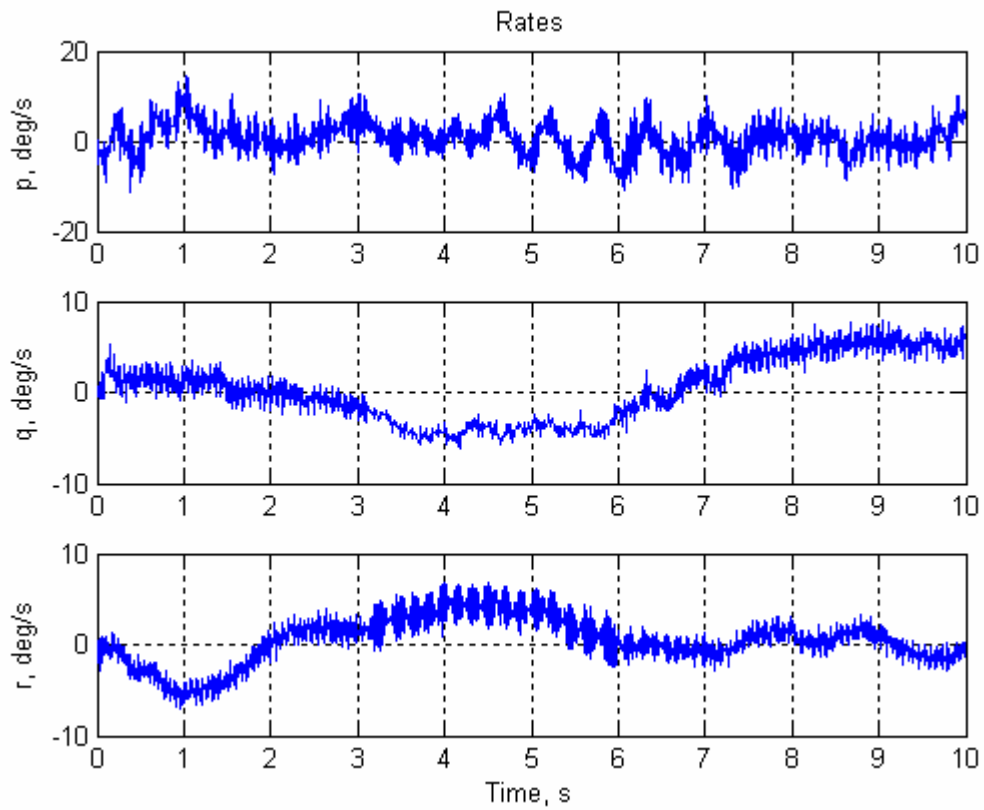


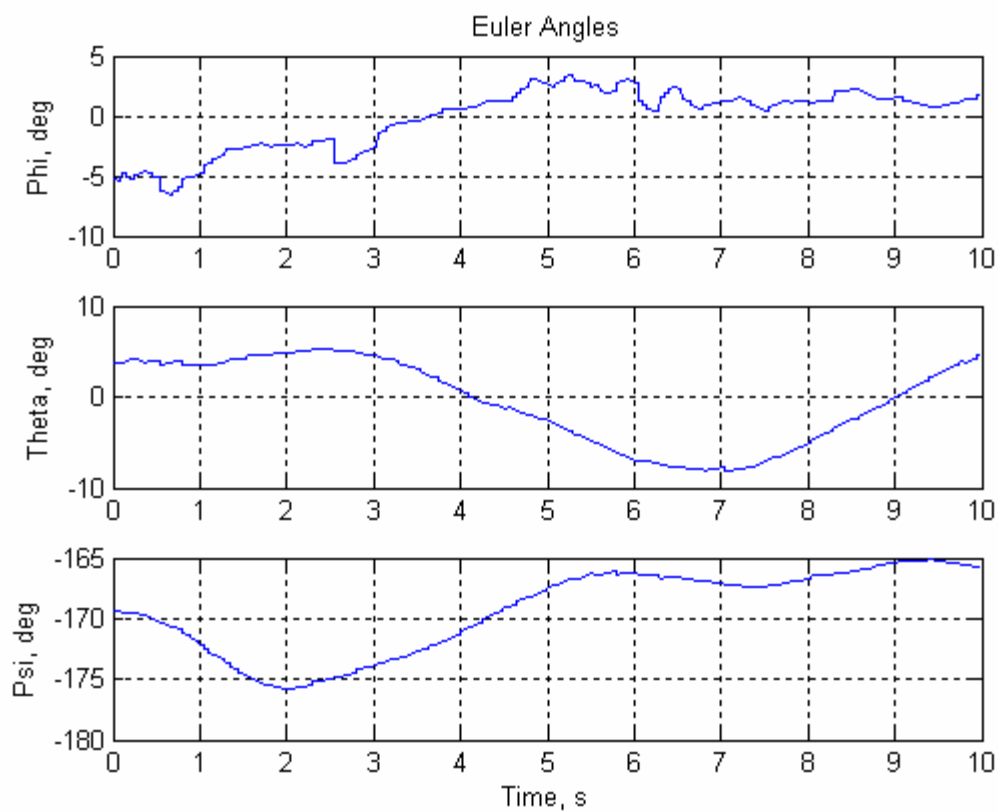
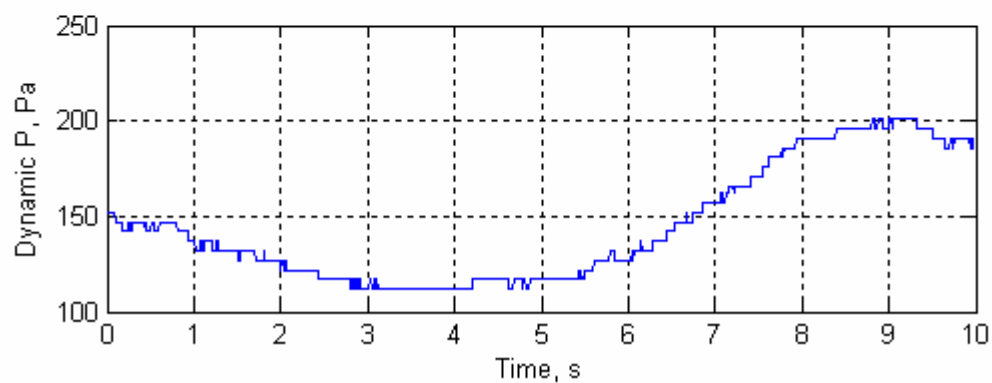
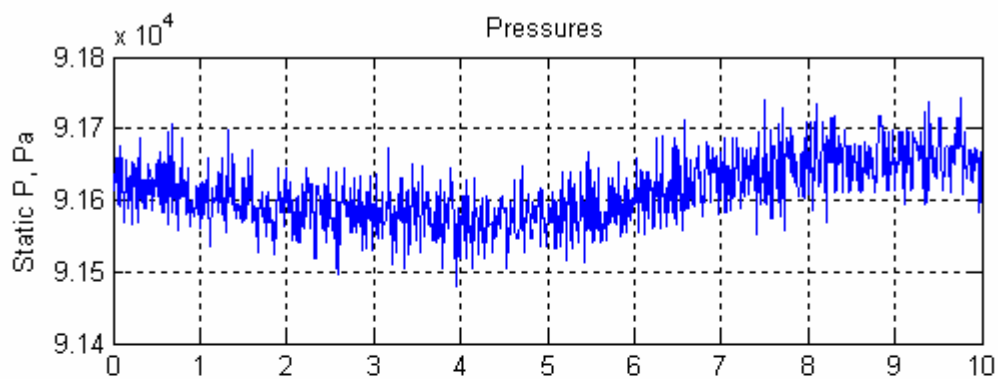




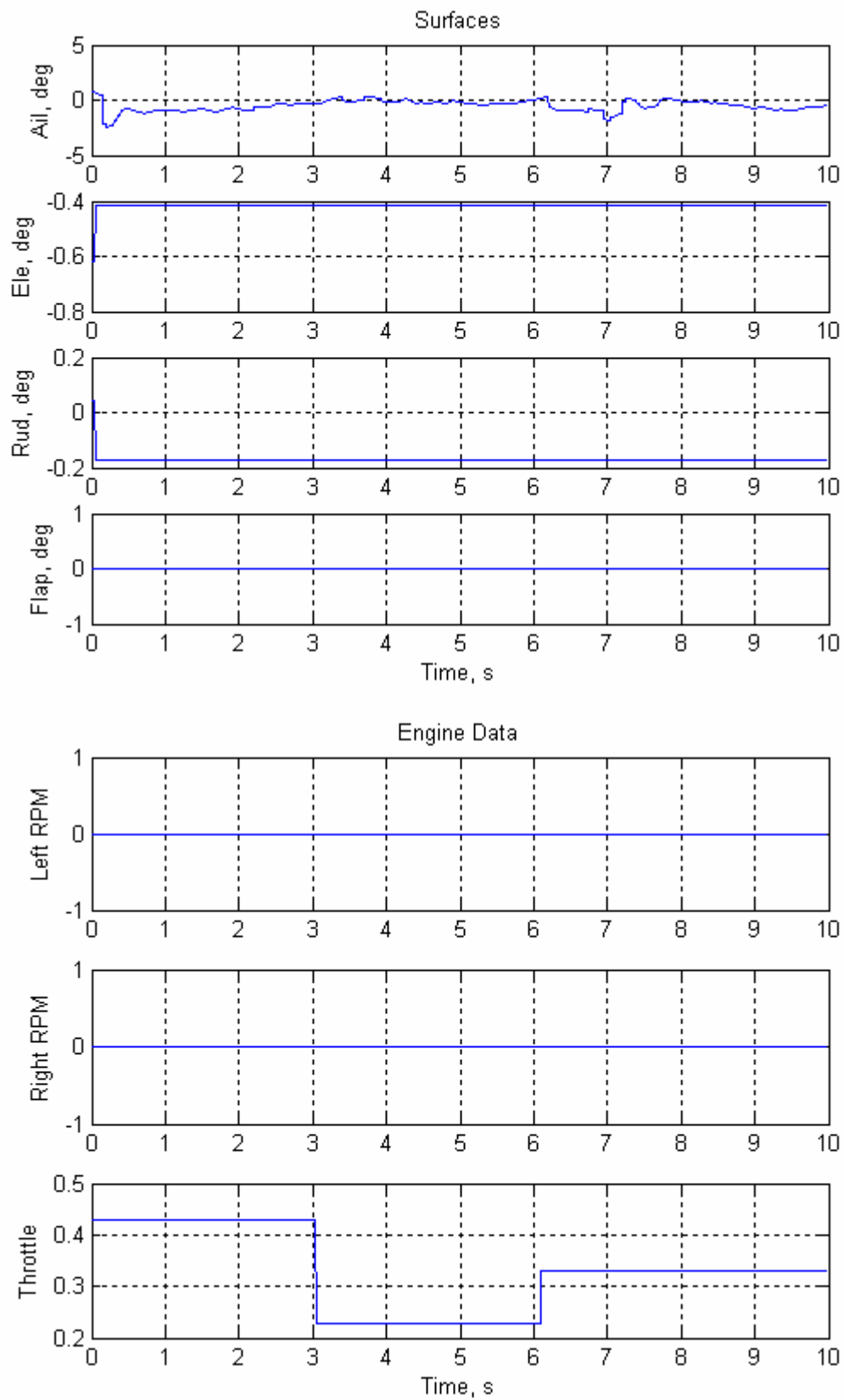
1.3.5 Throttle Doublet 1.

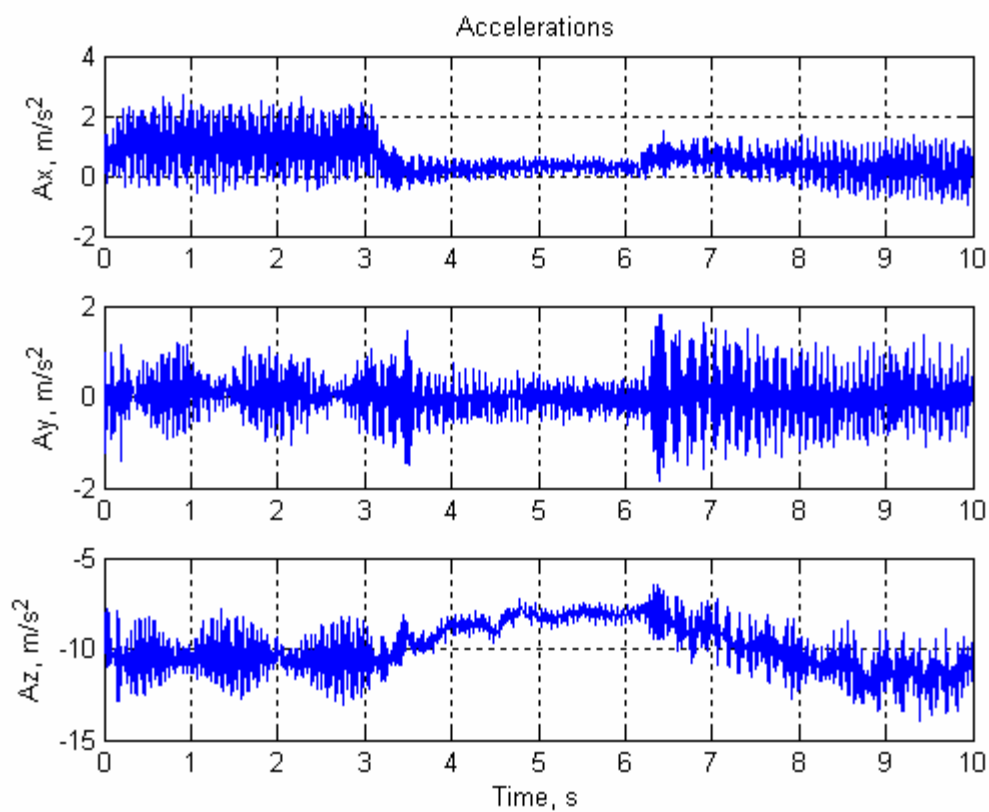
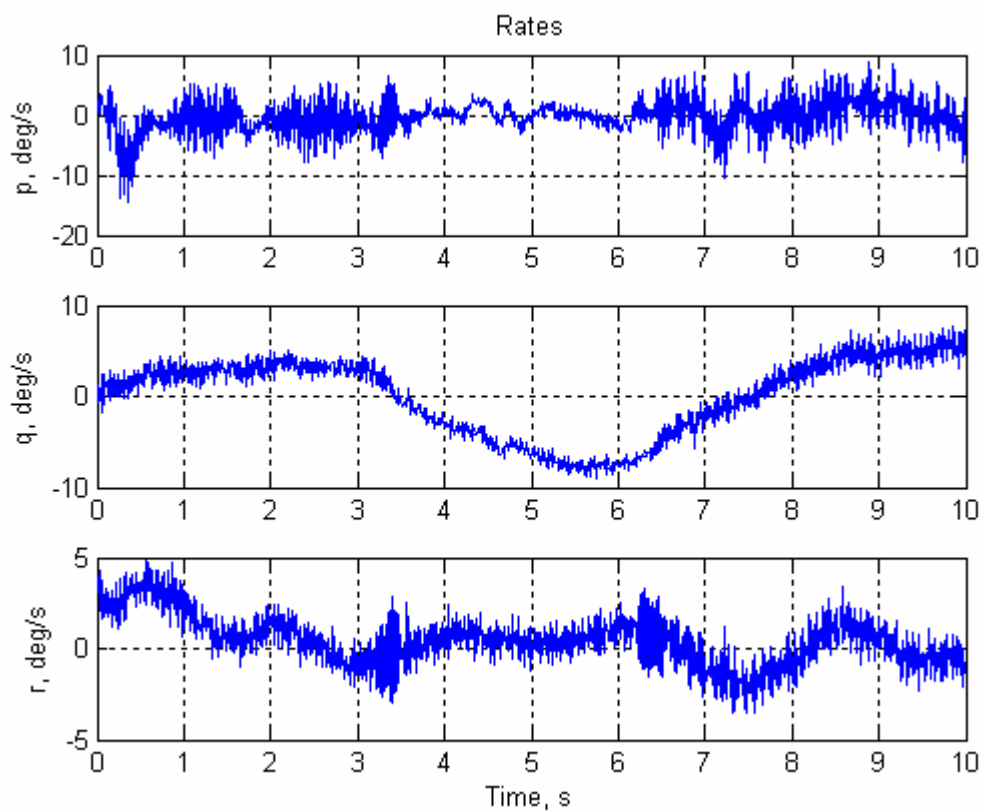


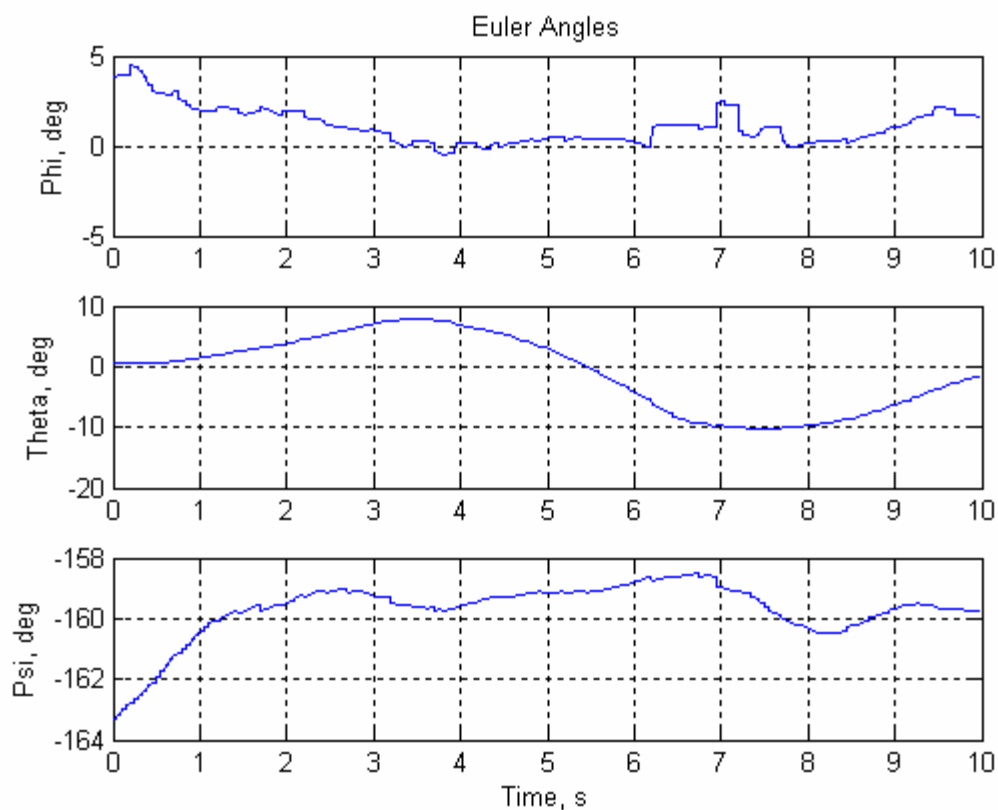
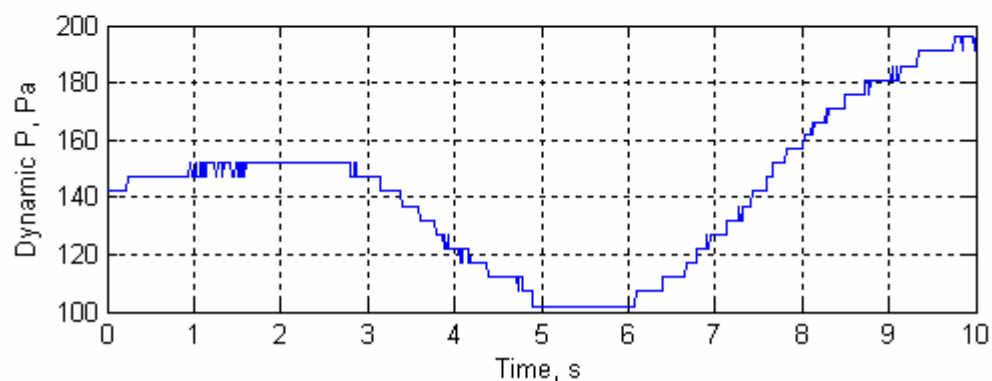
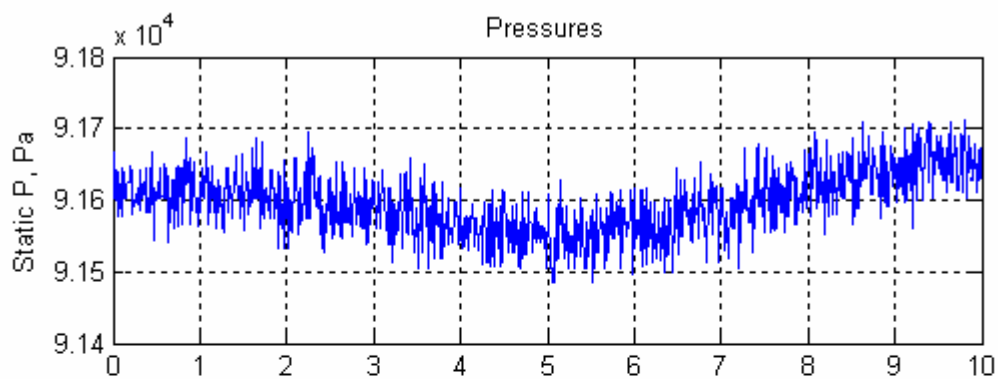




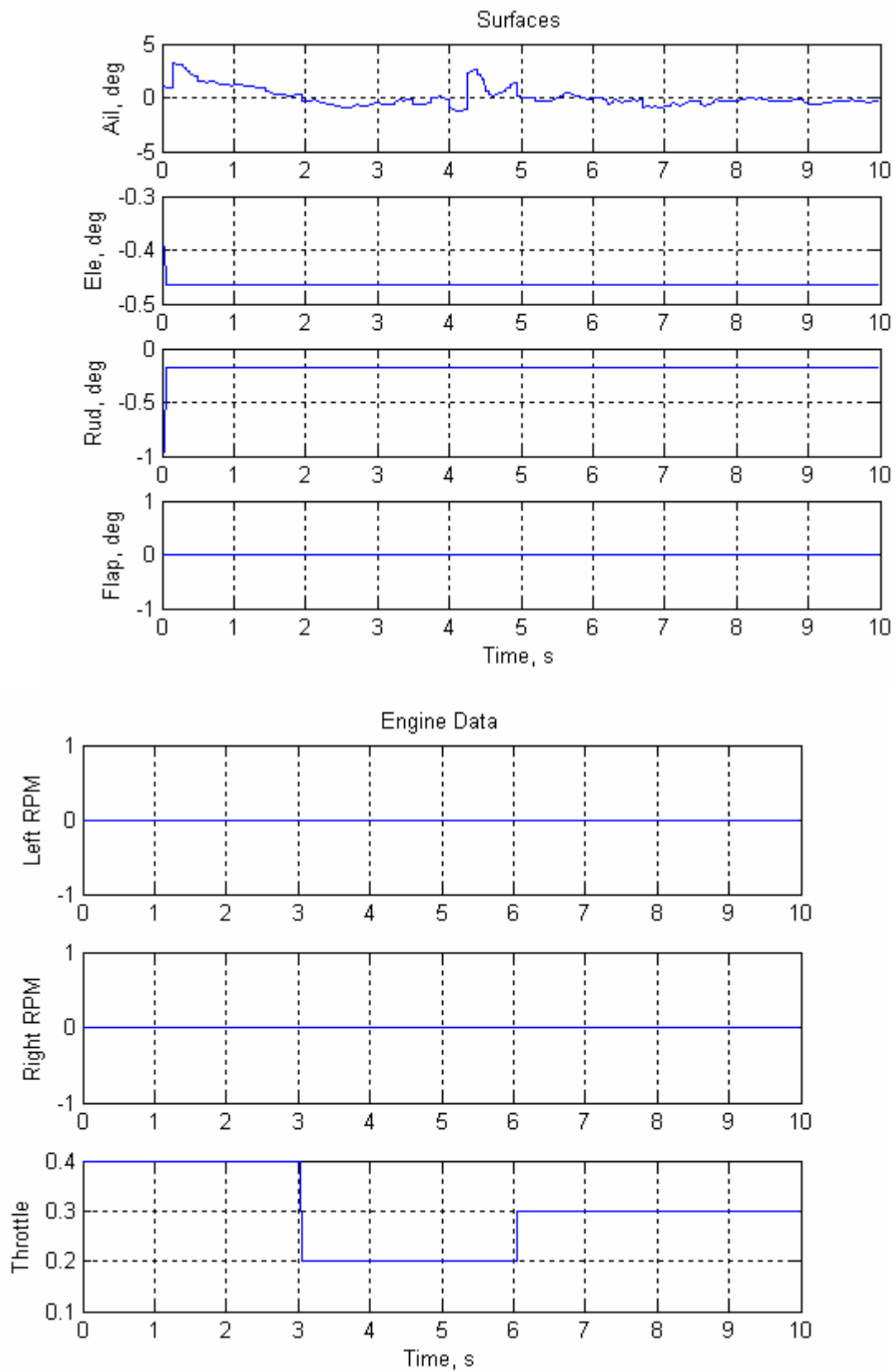
1.3.6 Throttle Doublet 2.

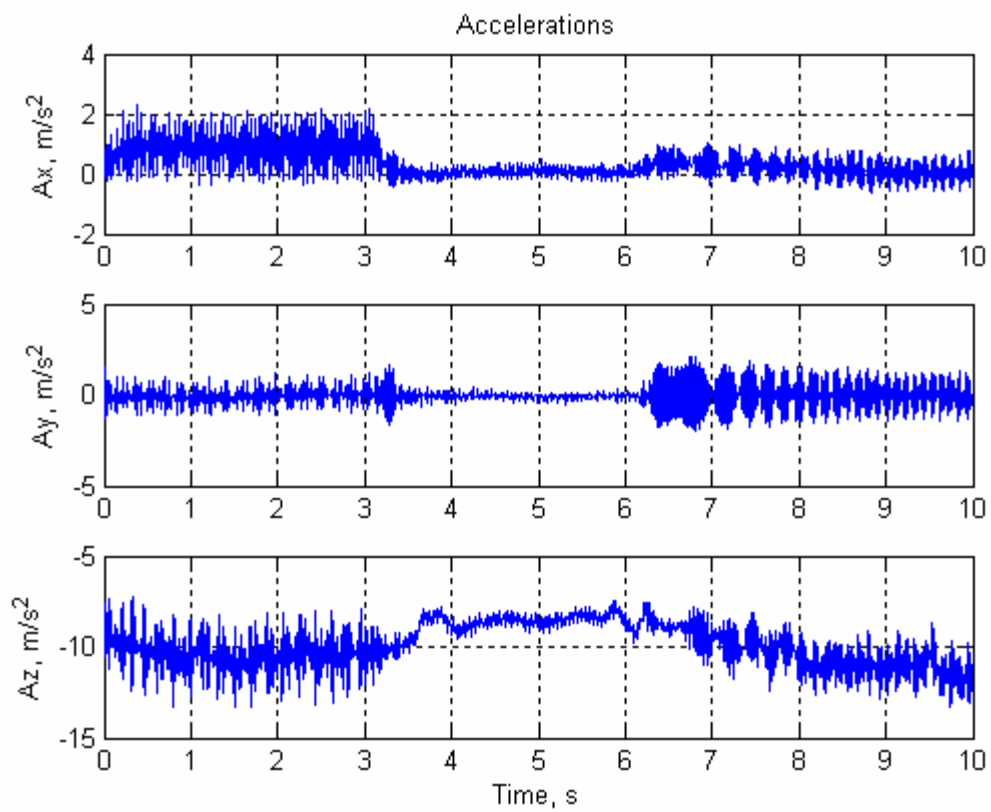
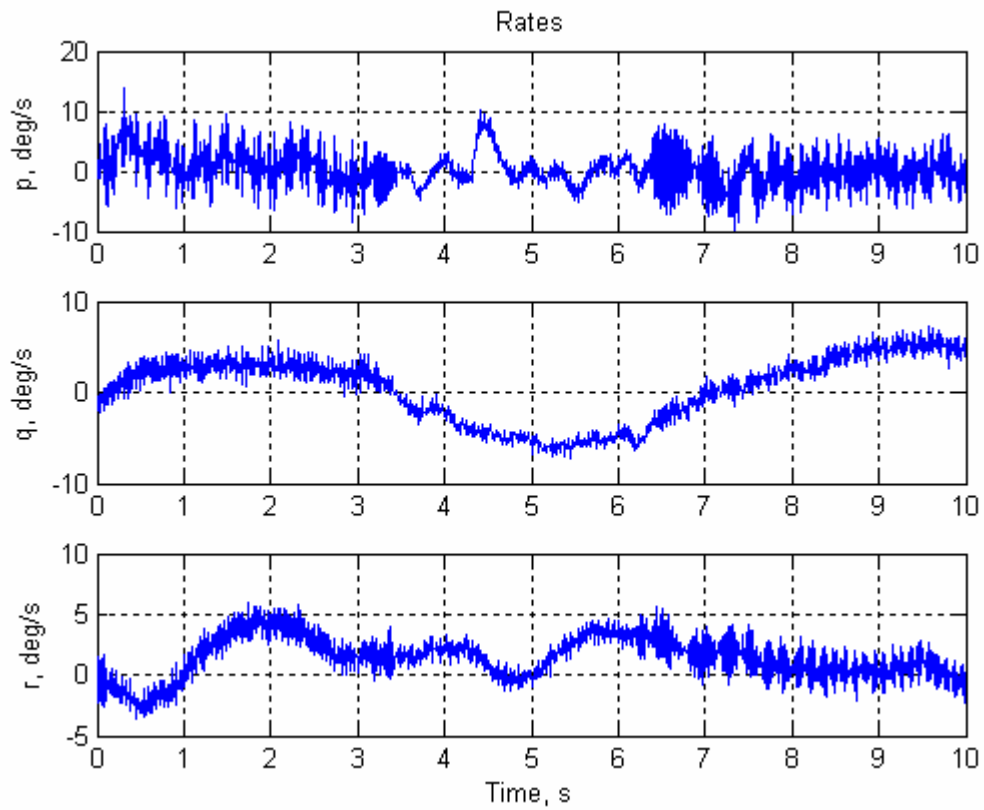


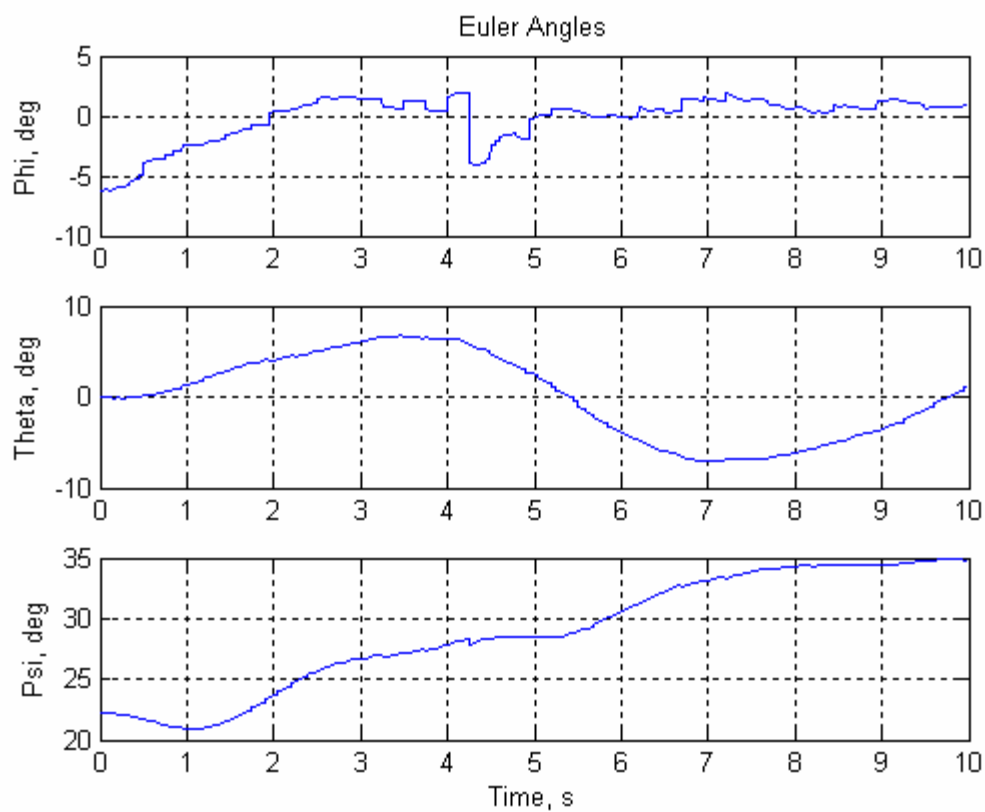
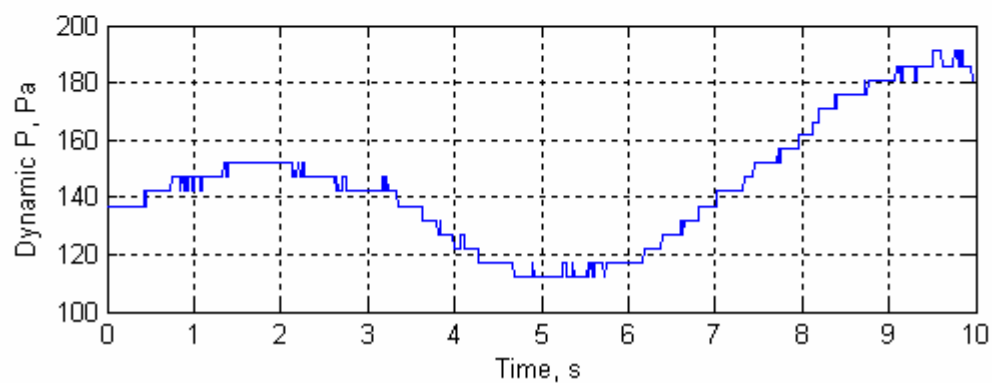
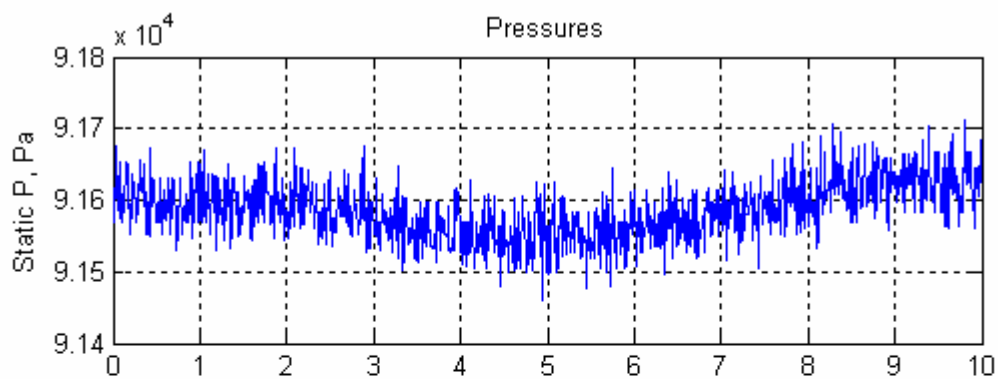




1.3.7 Throttle Doublet 3.

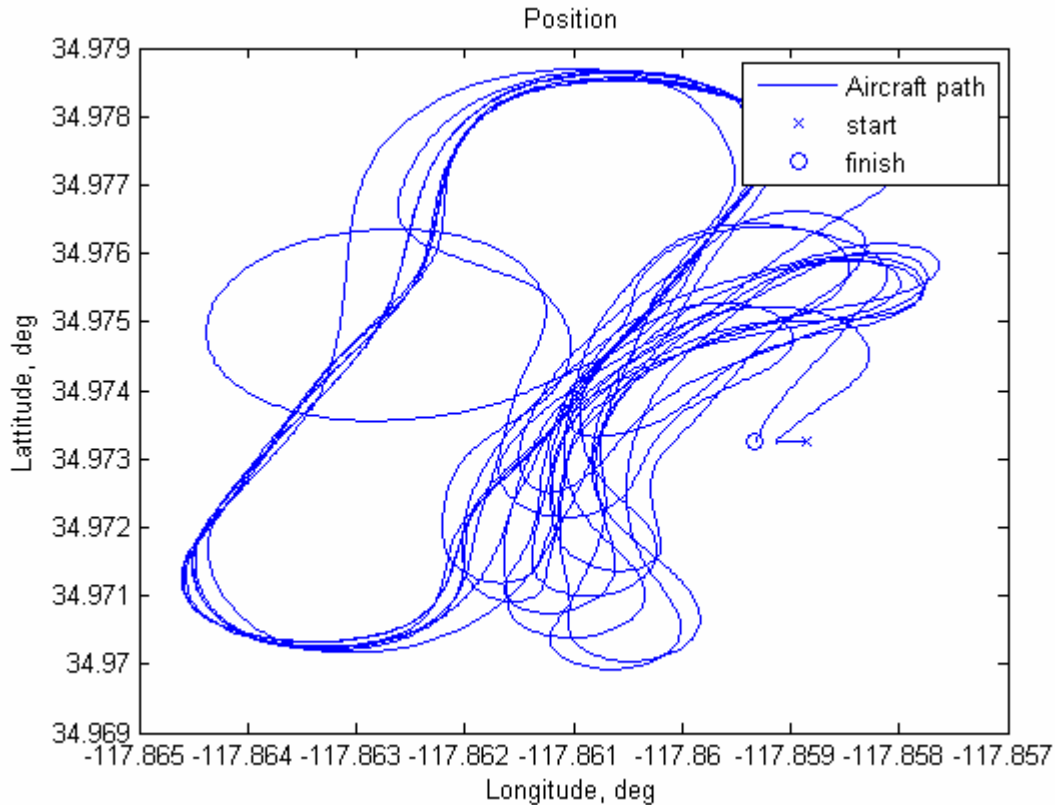


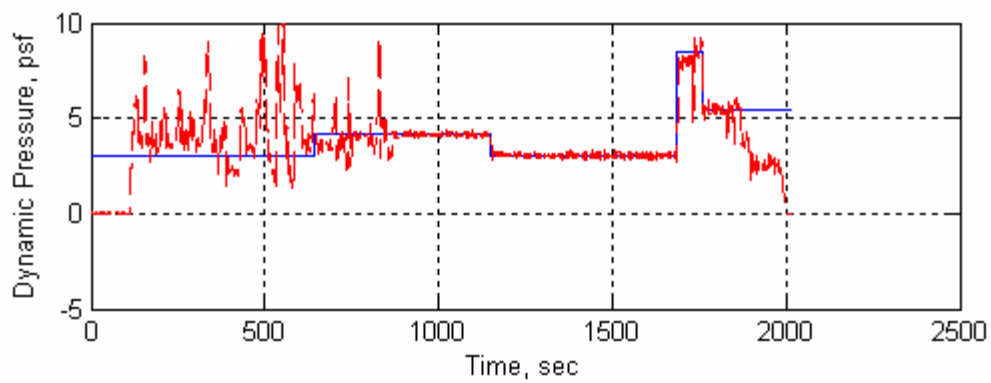
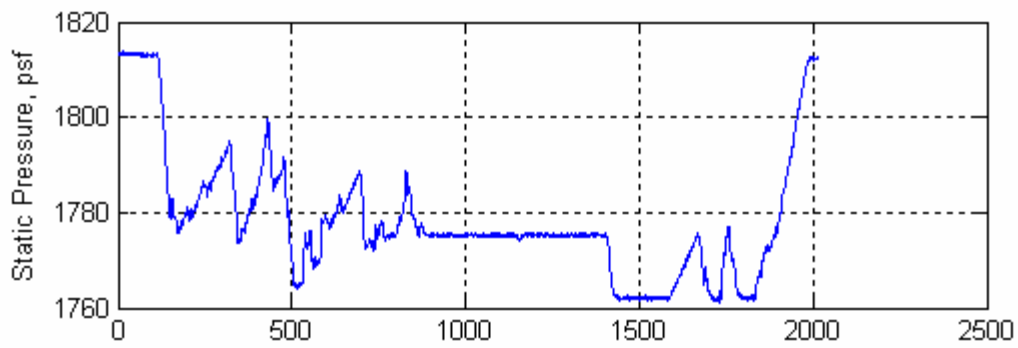
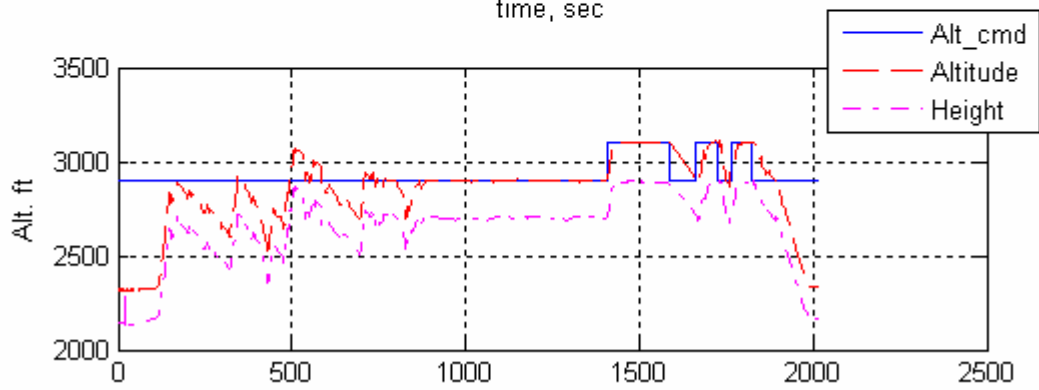
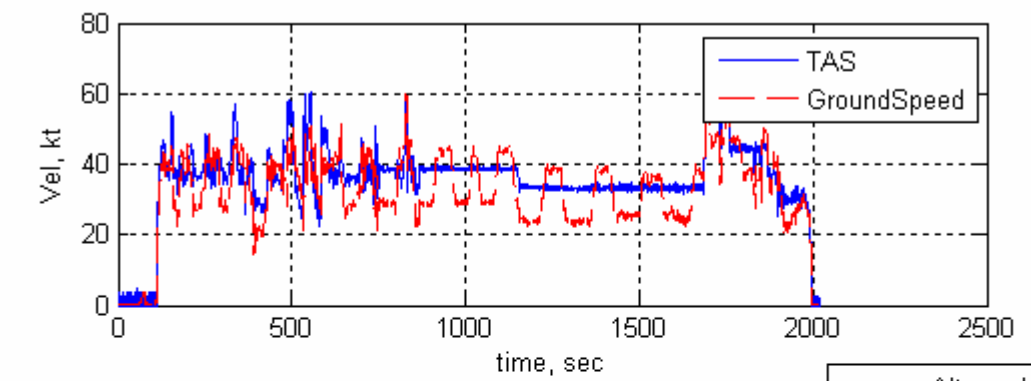


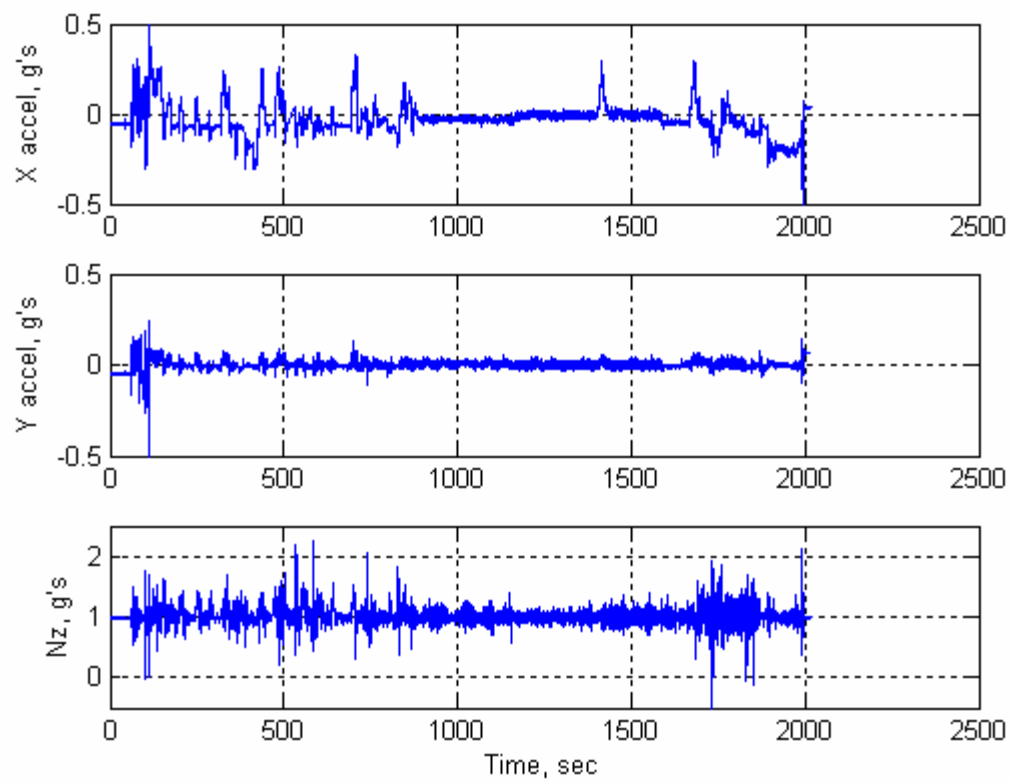
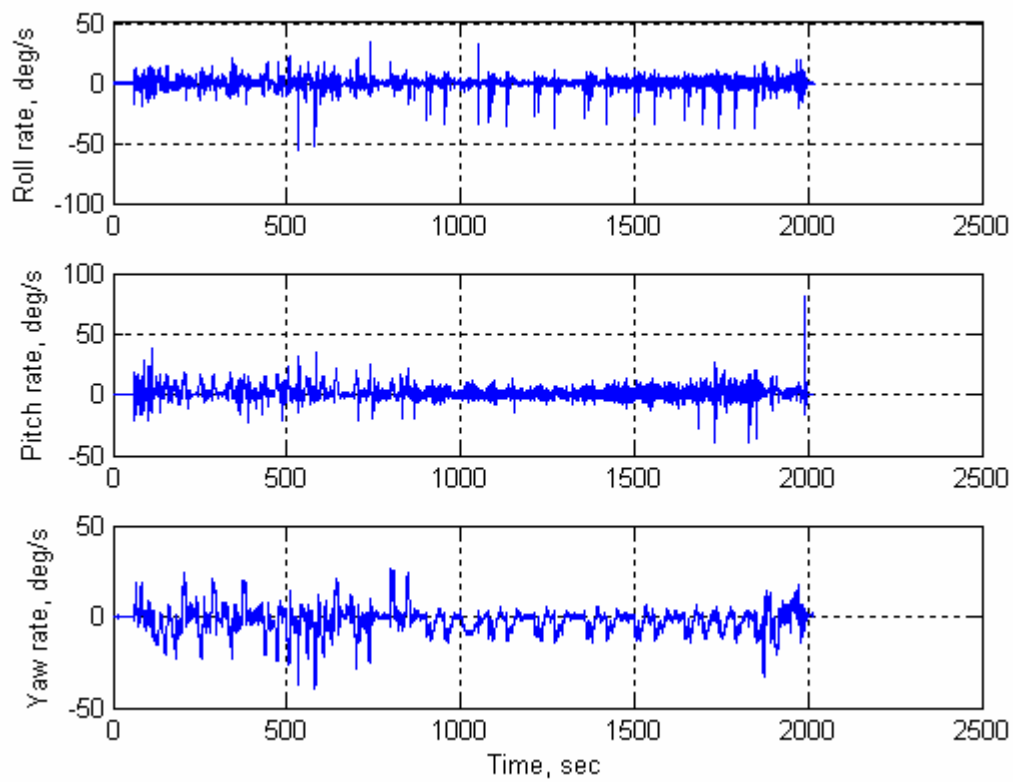


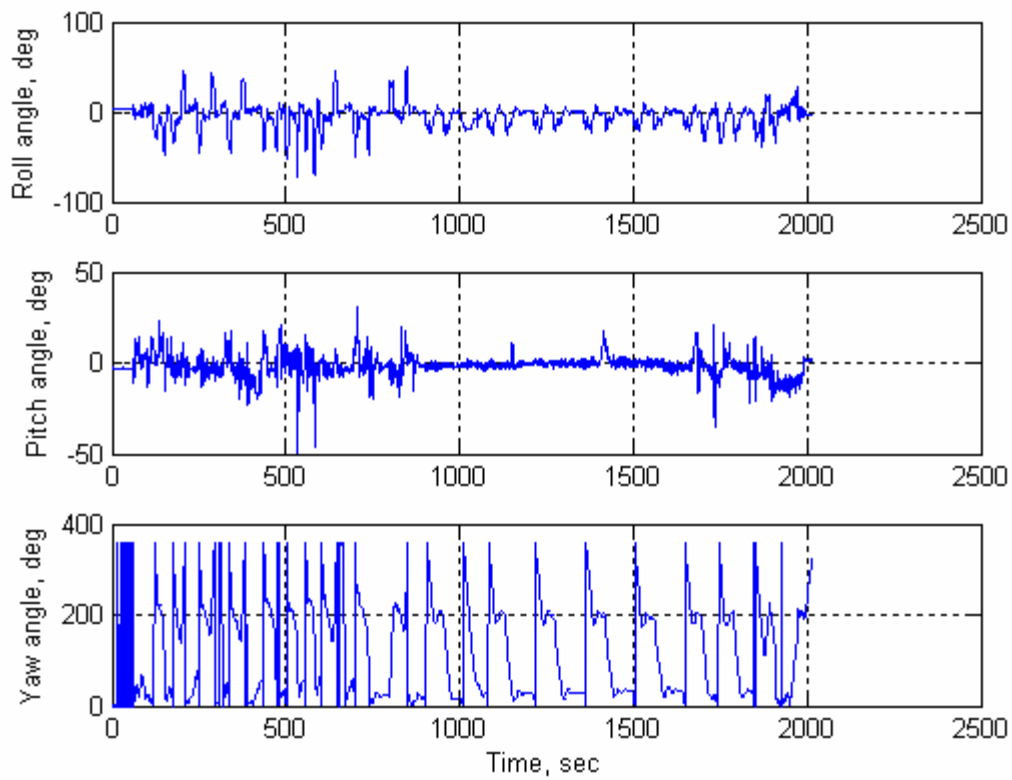
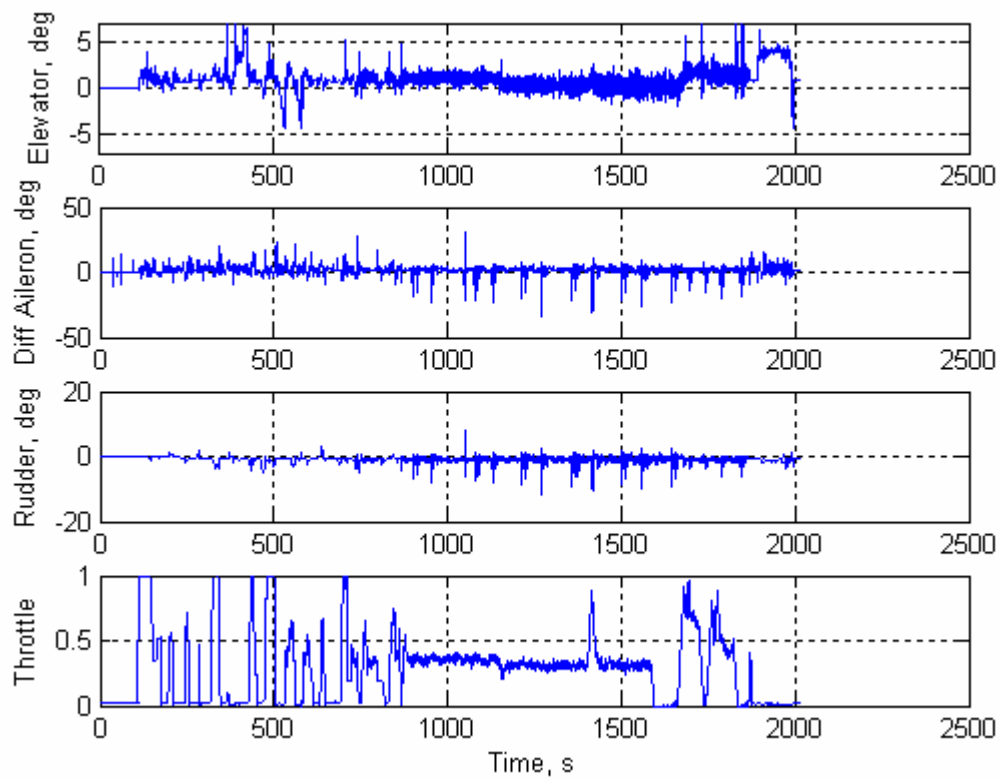
1.4 Cloud Swift 2, Flight 1

Data taken during three flights in December of 2006 were used to collect PID data using the Cloud Swift-2 aircraft. These maneuvers may include information from all three data sources (Piccolo, Doublet file, MFDRS). Maneuvers that include MFDRS data have surface positions, angle of attack, and sideslip angle in addition to the standard input set. Flight 1 occurred on December 7, 2006 from 19:29:06 – 20:02:43 UTC (11:29:06 – 12:02:43 local). Flight 1 was used to perform pilot checkout of the airframe, verify the orbit path of the lost link waypoint, measure the stall characteristics, and conduct speed polar maneuvers.





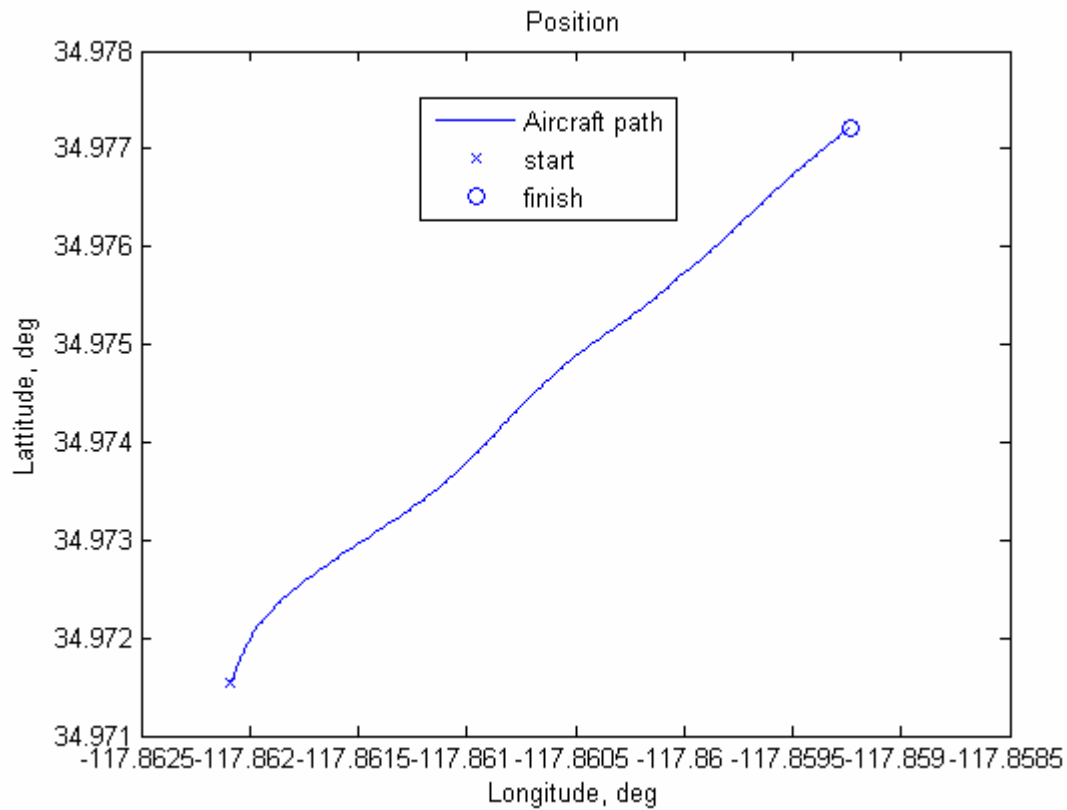


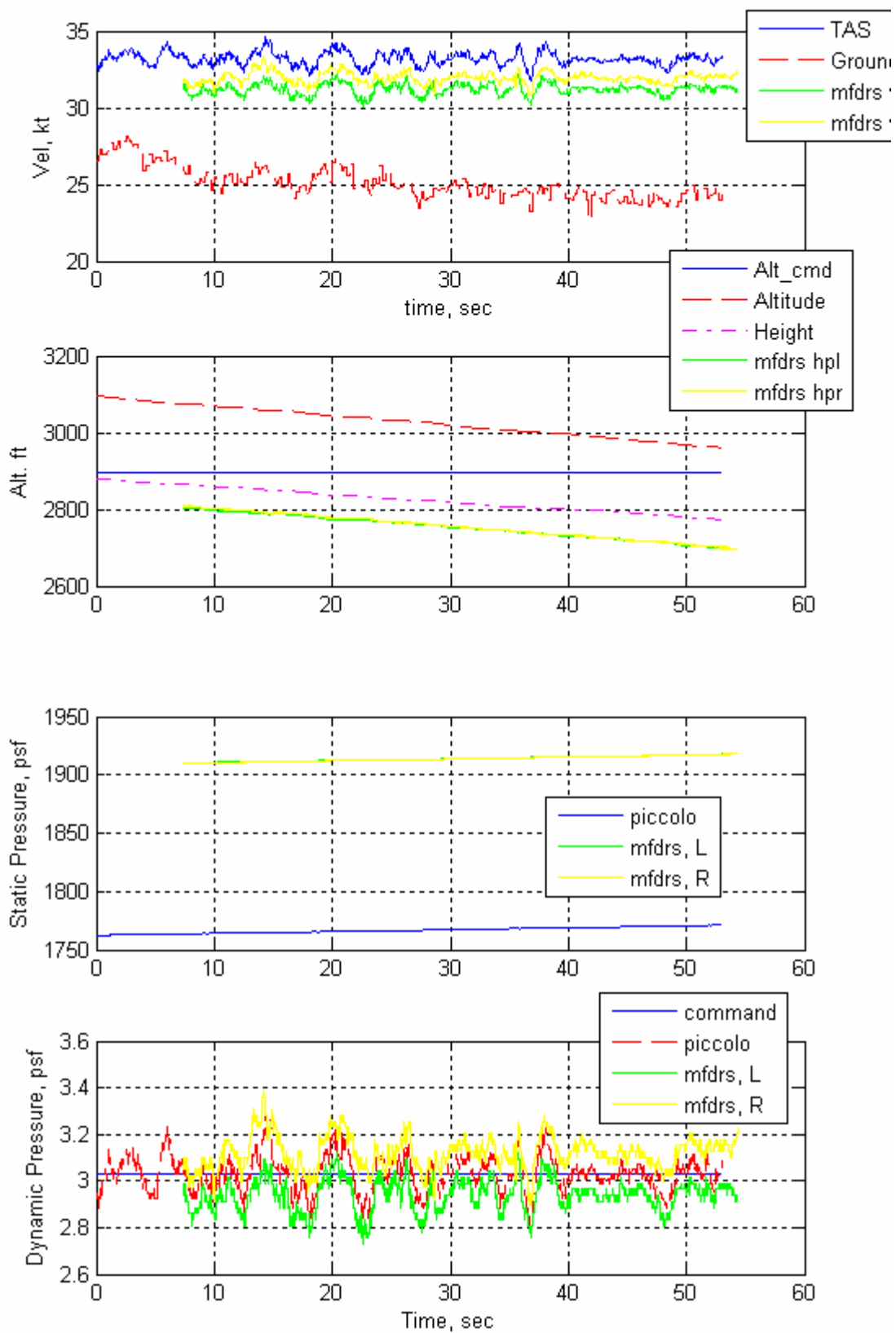


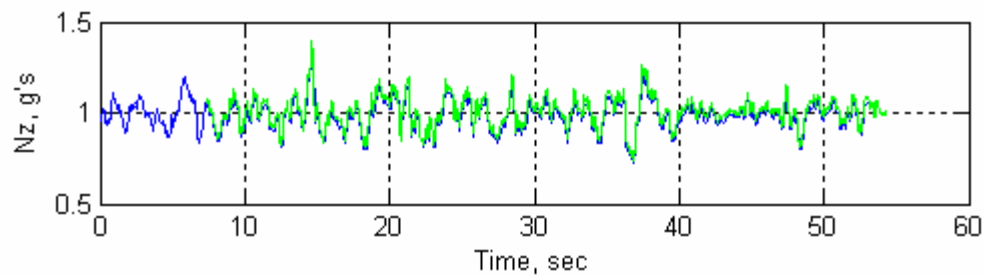
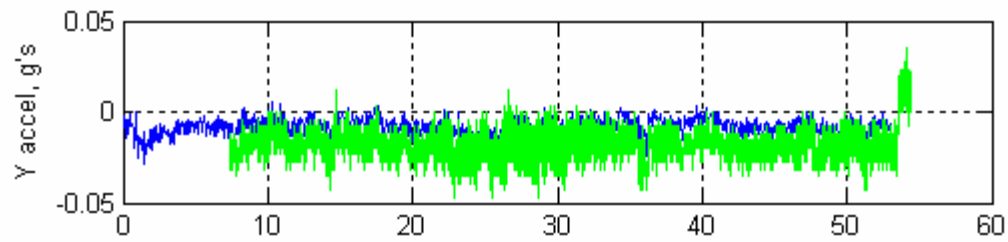
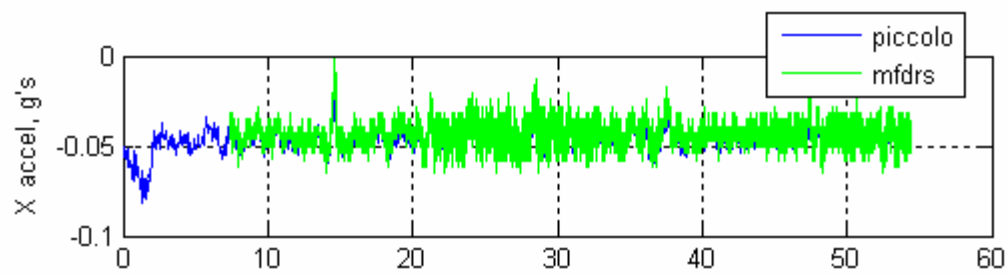
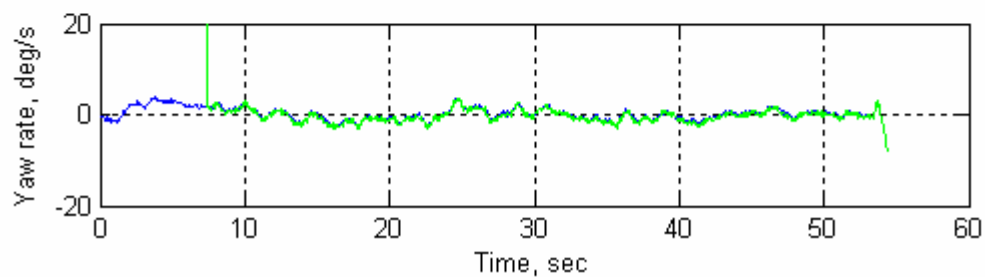
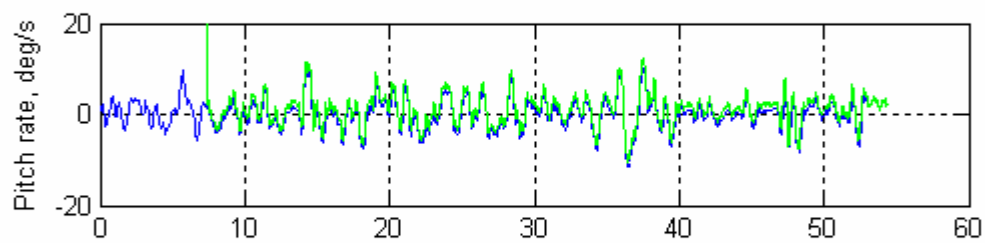
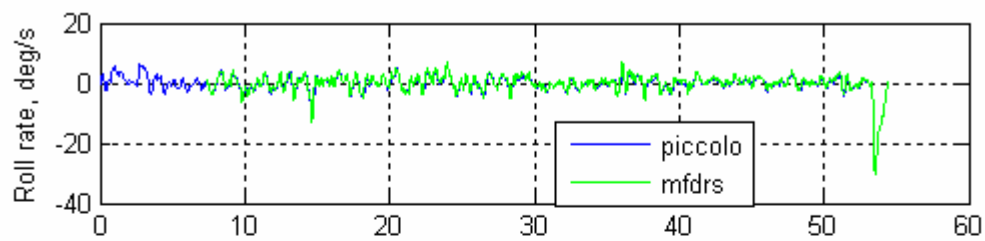
1.4.1 35kt Glide

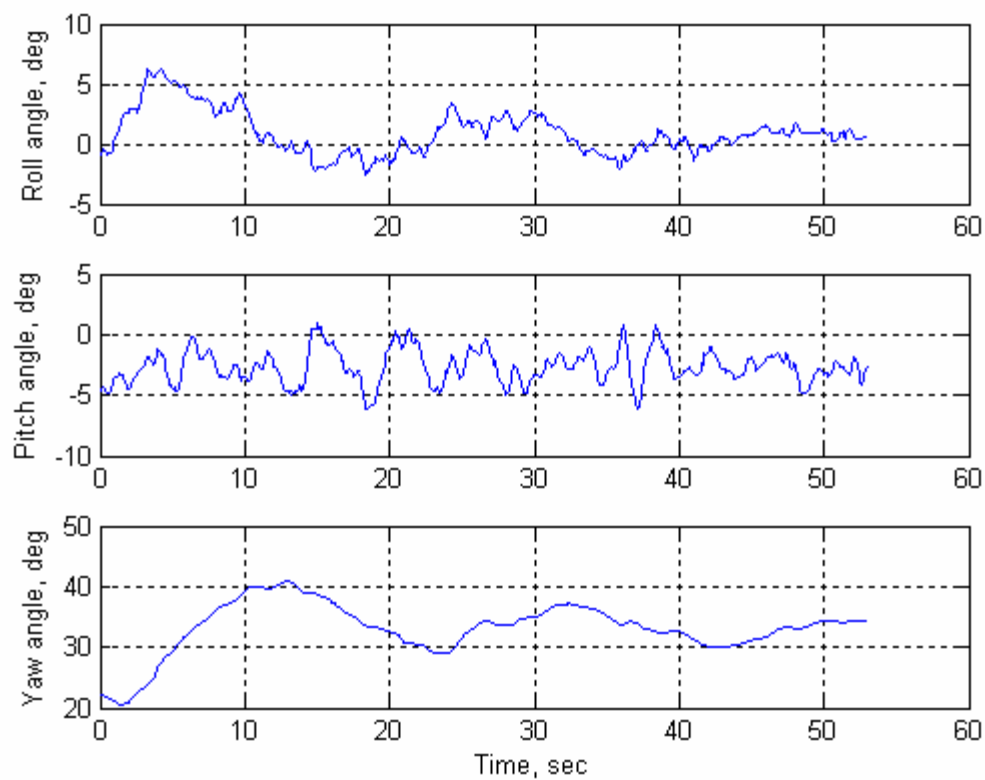
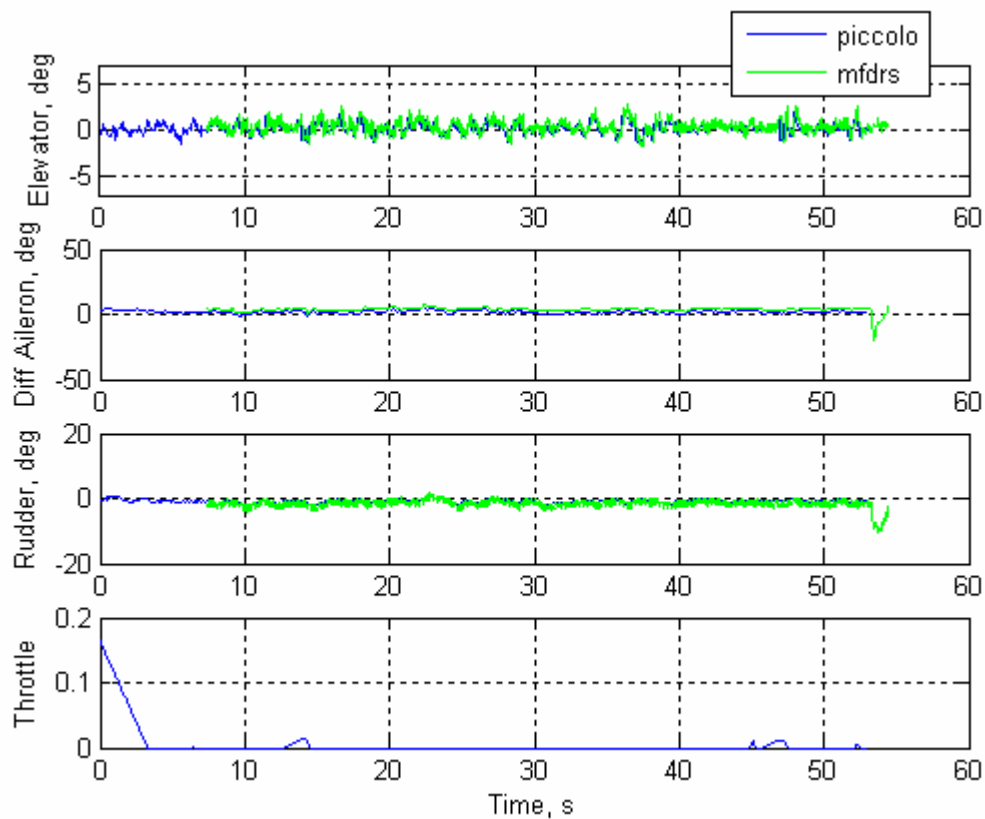
The aircraft was flown power off at different speeds to capture the speed polar of the aircraft. These maneuvers were done autonomously while tracking waypoints. Doublet maneuvers were used to mark the start and stop of the maneuvers. This method did not always work because the ground station operator had too many things to do in a short amount of time.

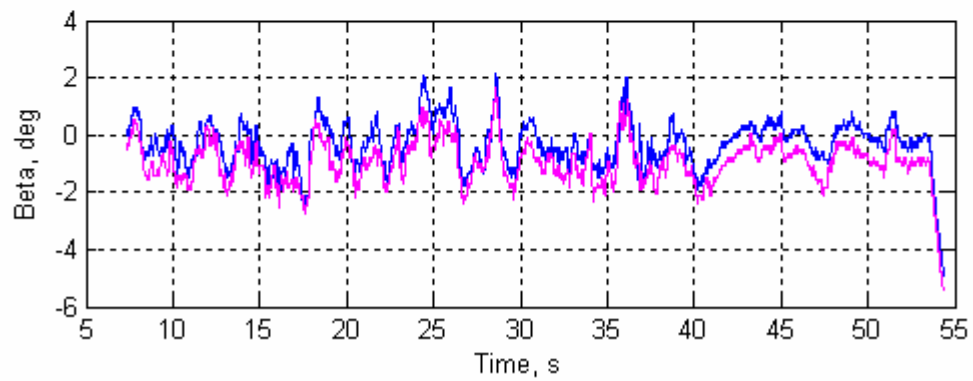
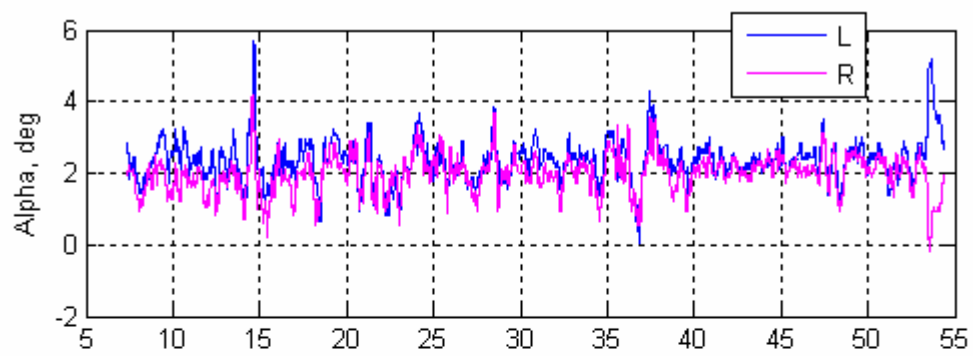
MFDRS data included. Two Pitch doublets were used to mark the beginning and end of the maneuver. Both doublets are broken out into separate files.





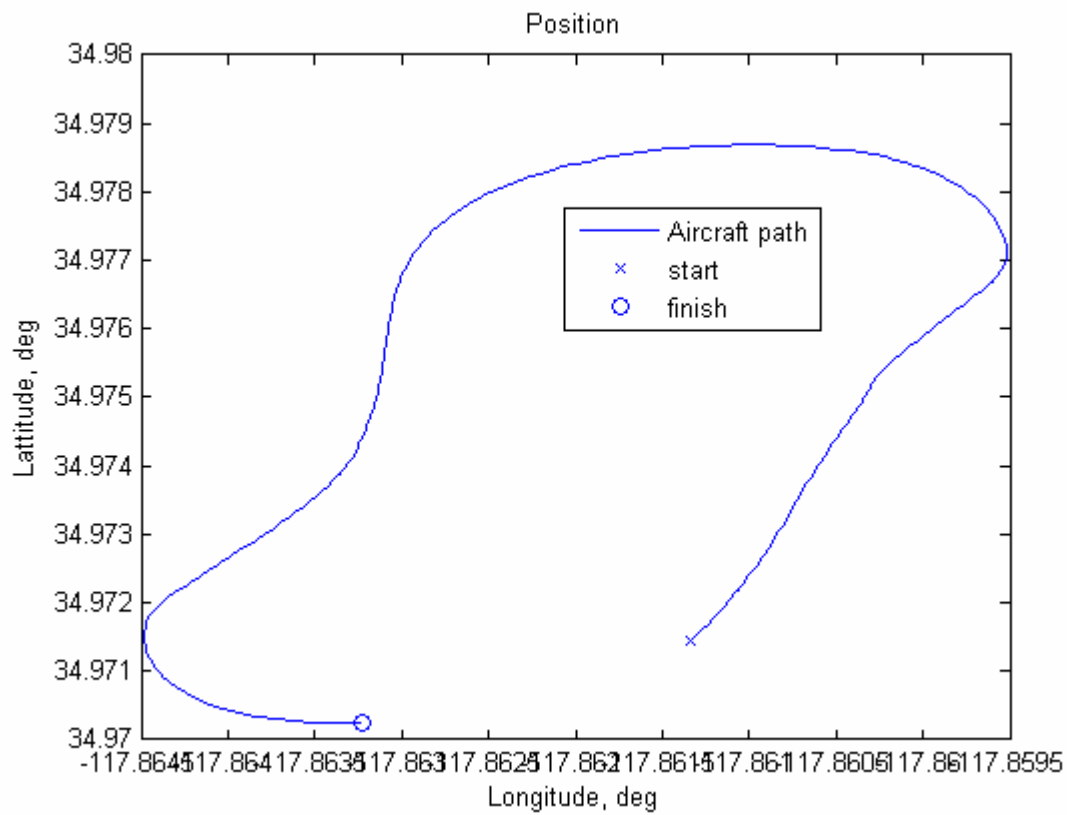


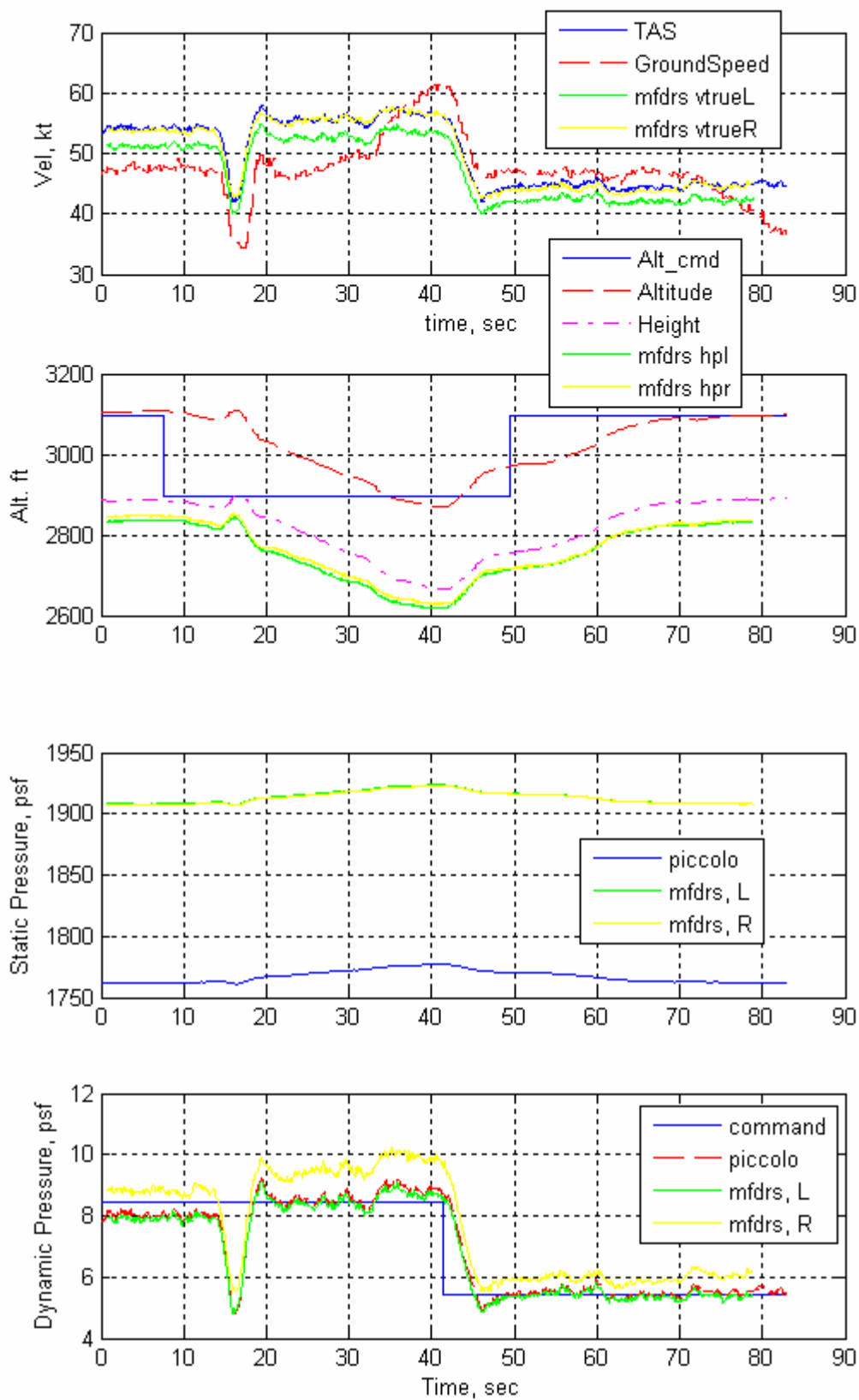


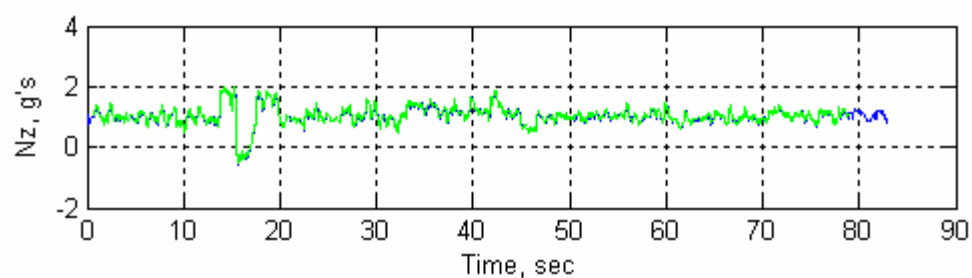
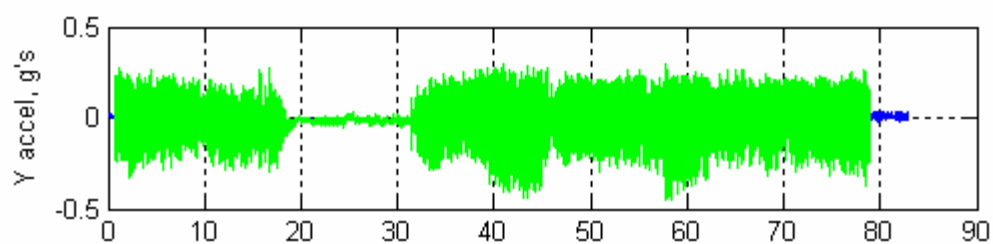
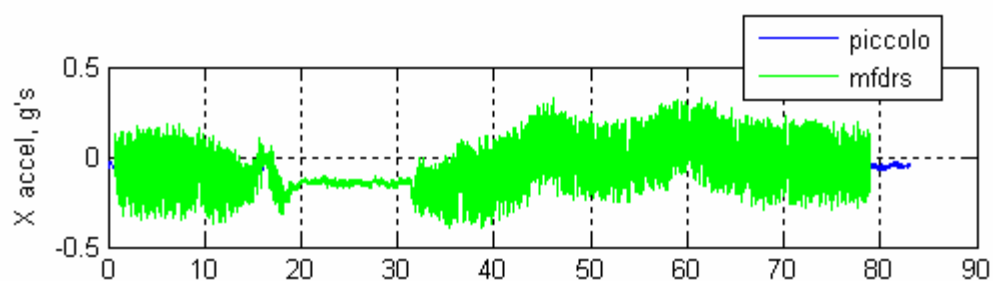
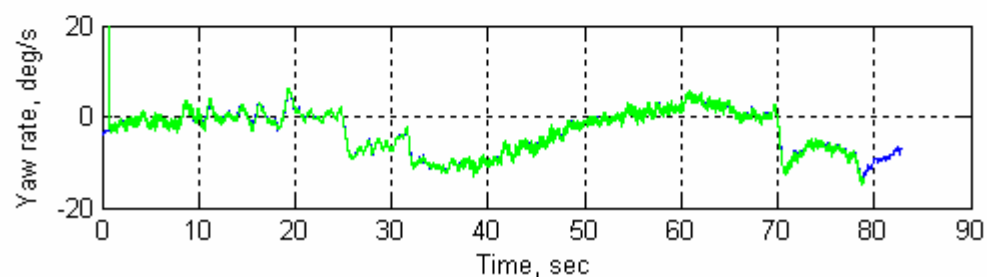
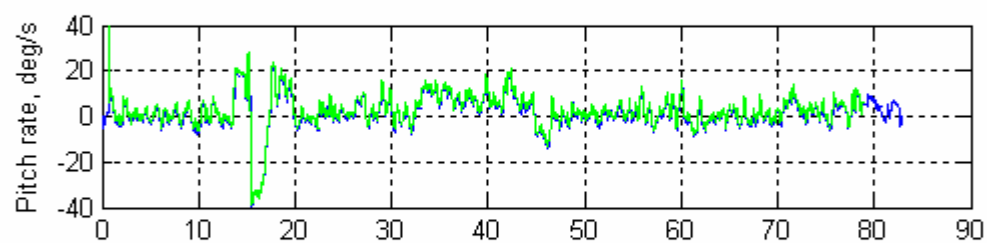
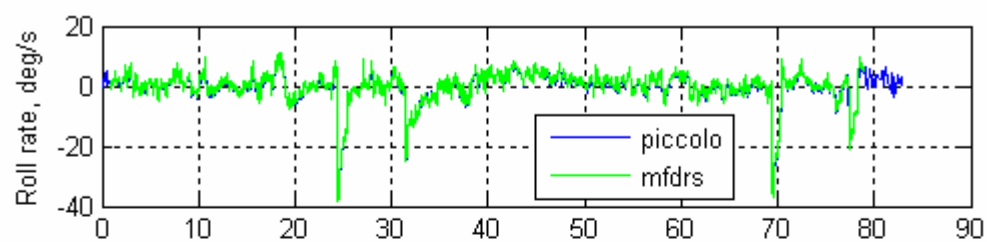


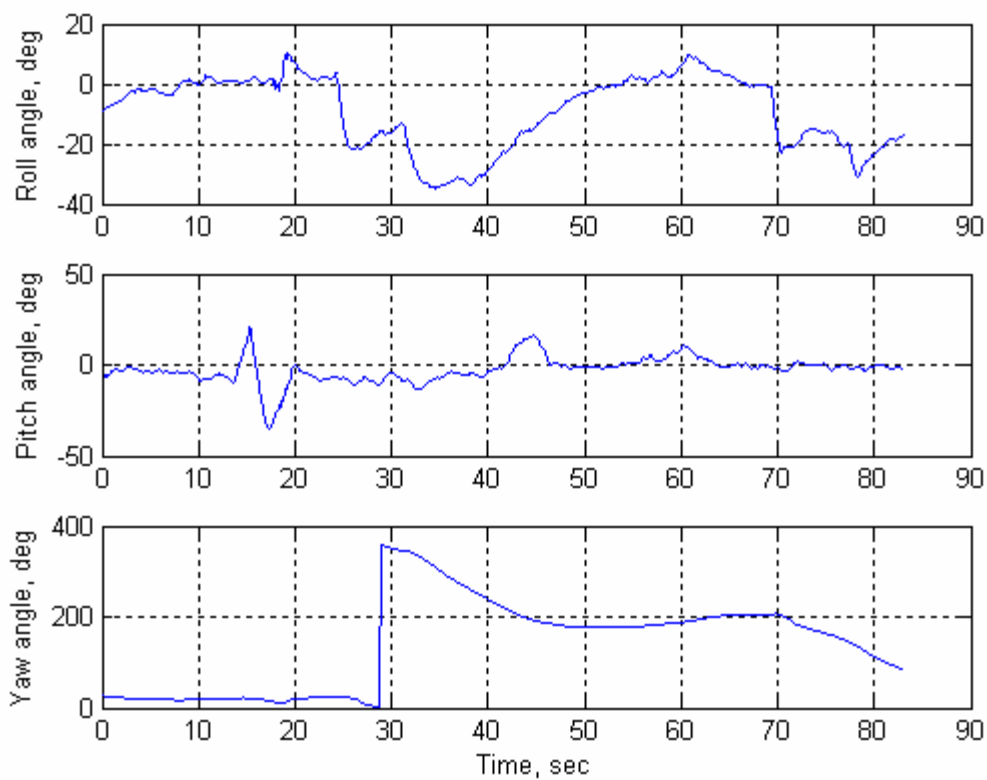
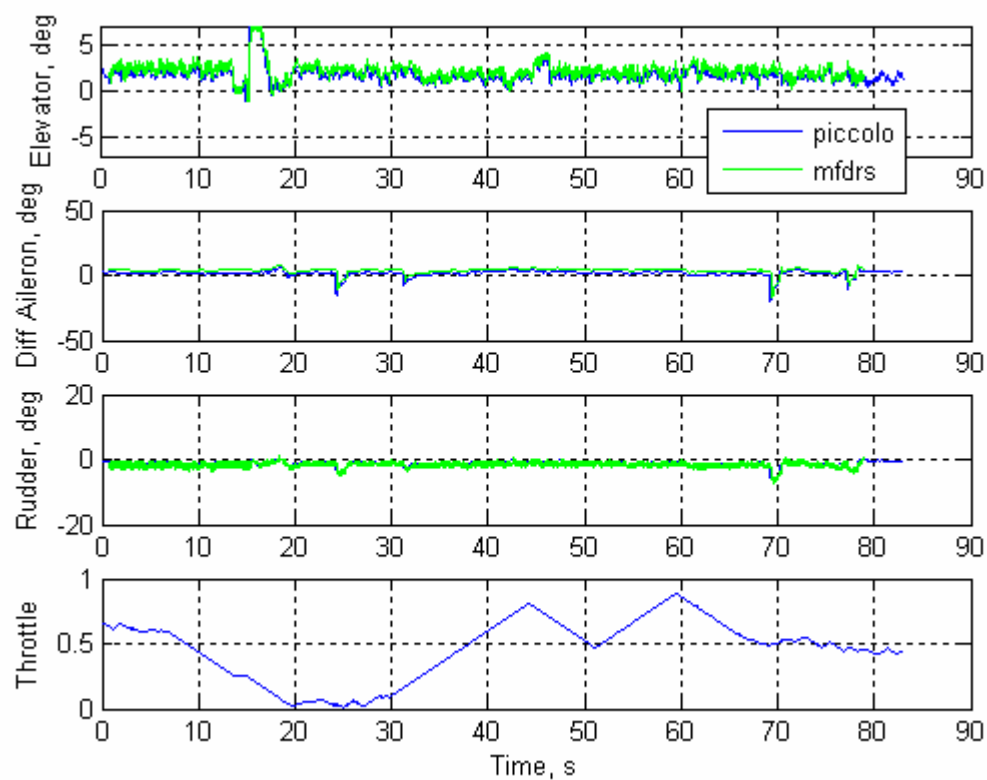
1.4.2 55kt Glide, Long

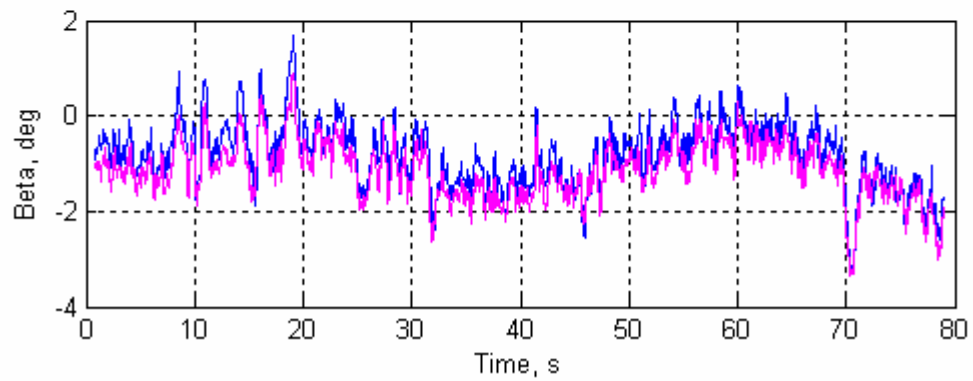
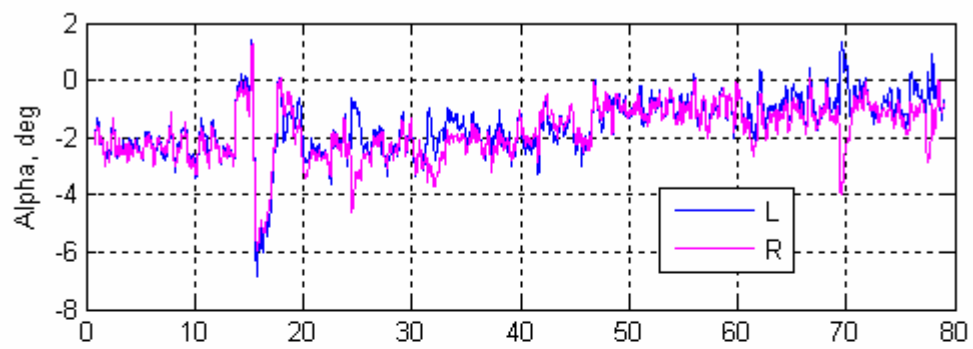
The procedure used to obtain the 55kt glide data did not produce zero throttle so the data is of limited use for performance calculations. The entire maneuver starting with setup, pitch doublet, recovery and setup for the next maneuver is included here with MFD RS data. Individual maneuvers are broken out and shown separately.



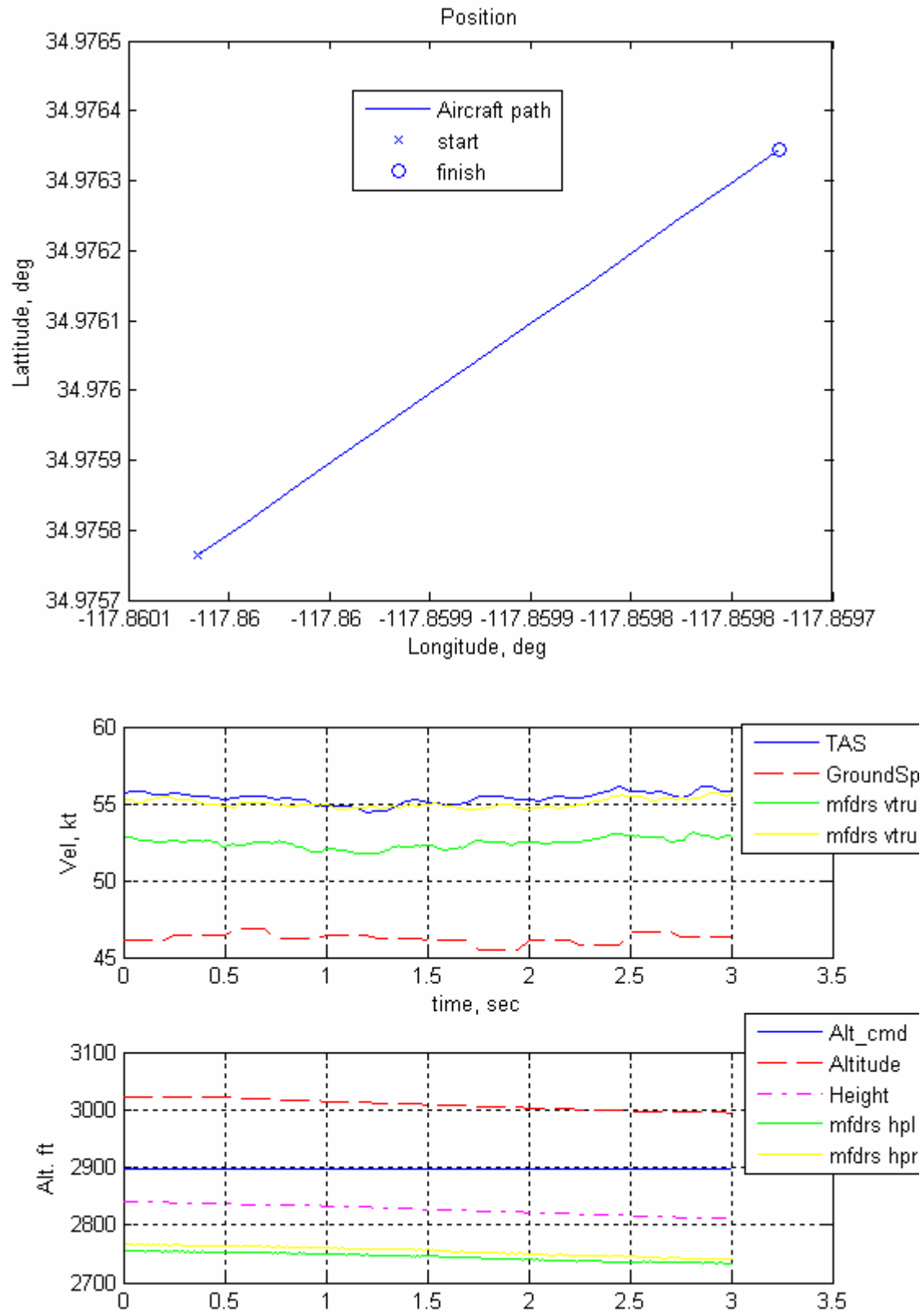


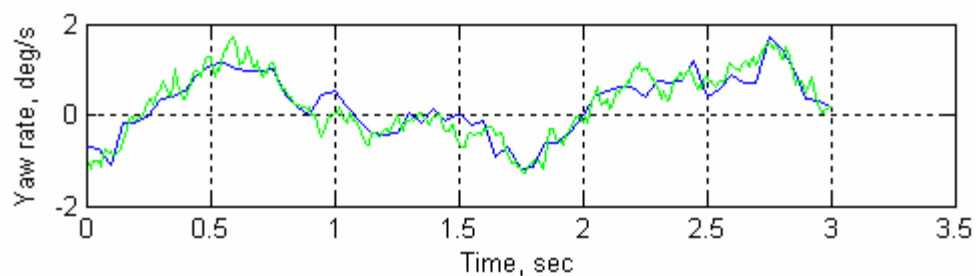
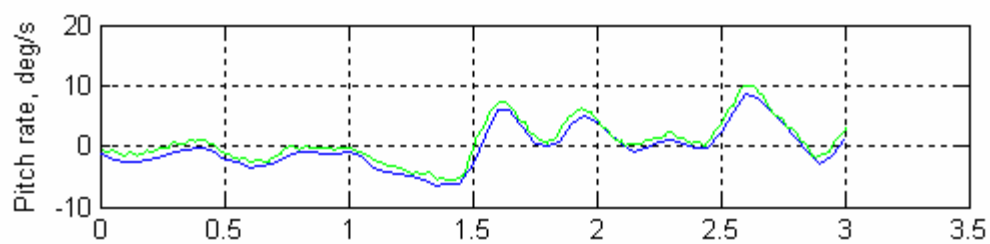
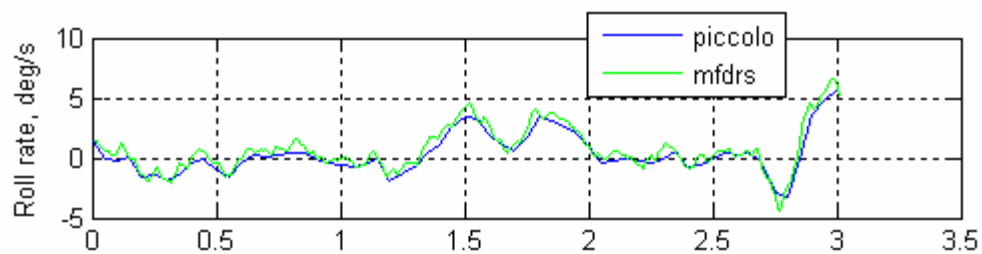
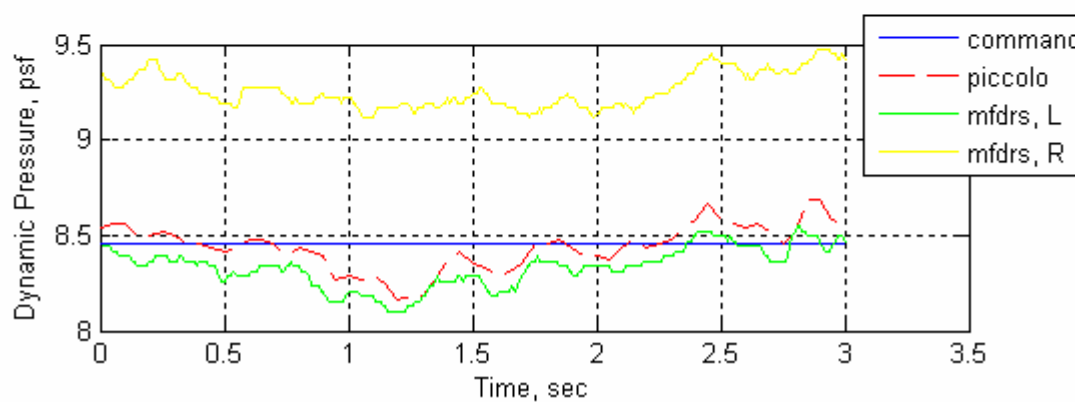
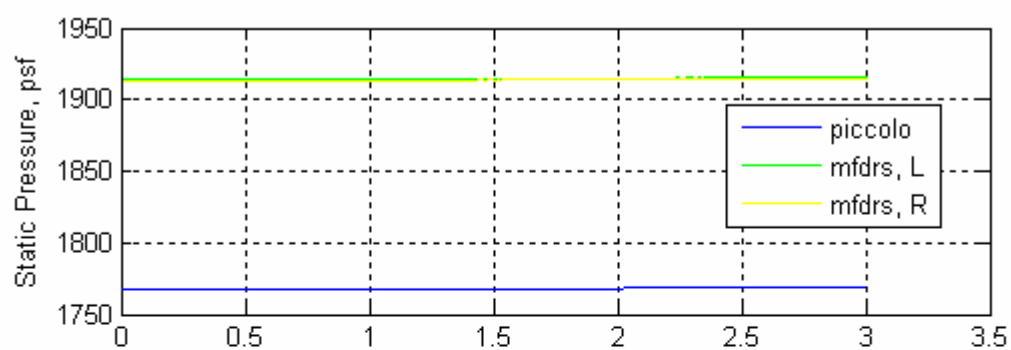


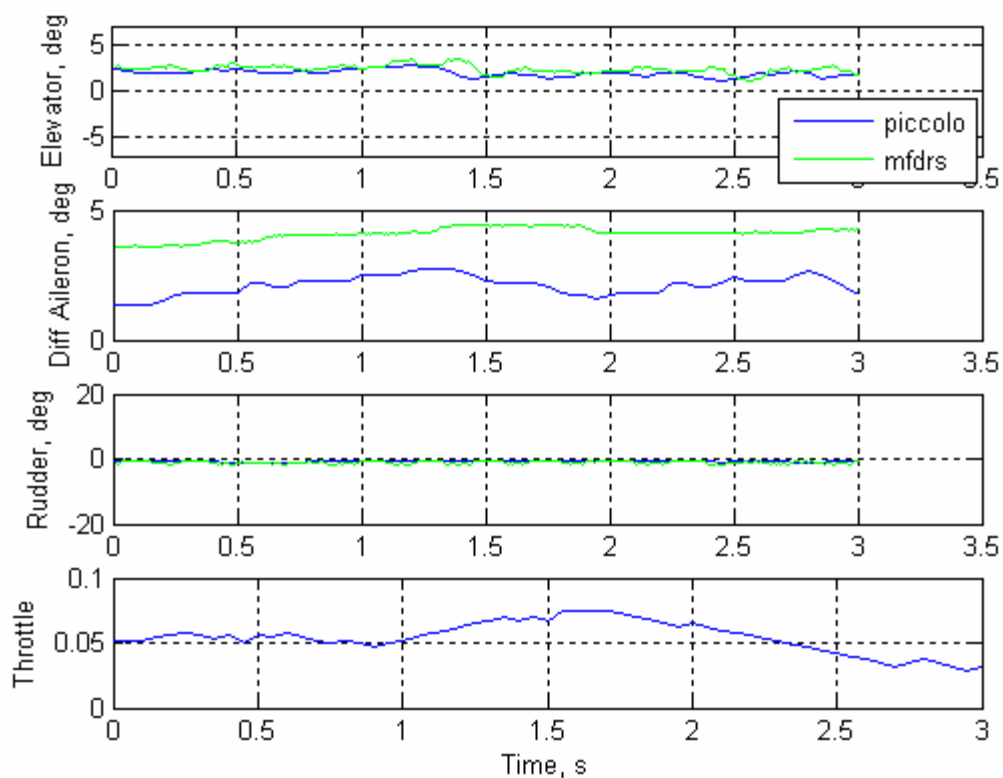
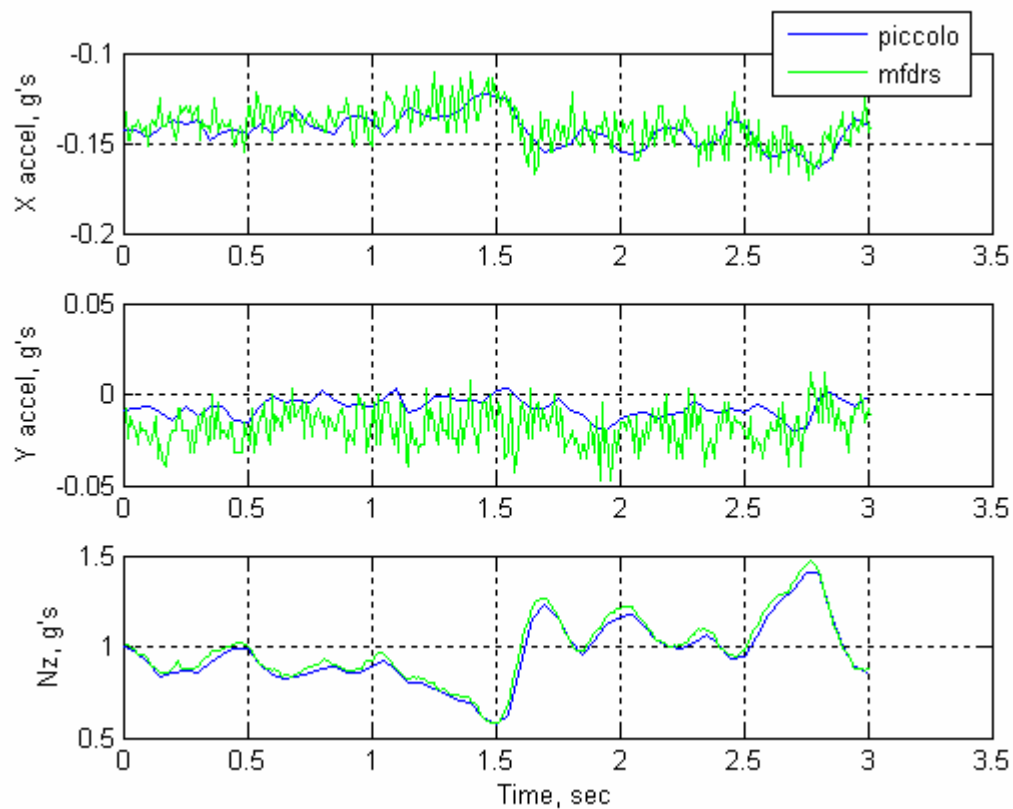


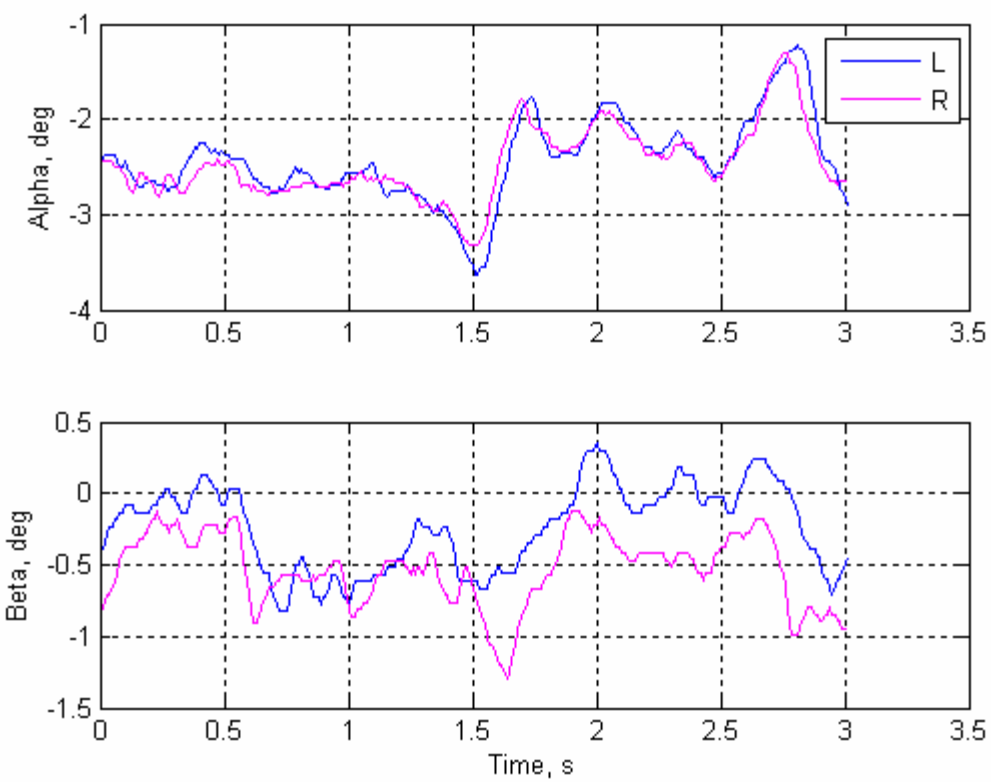
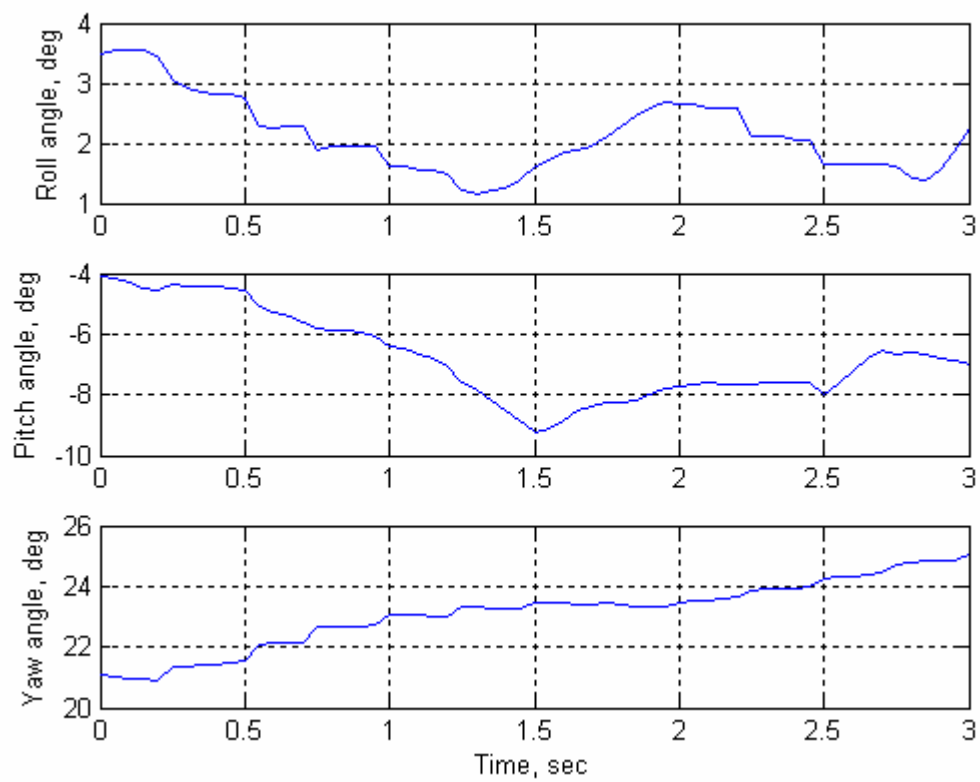


1.4.3 55kt Glide, Short



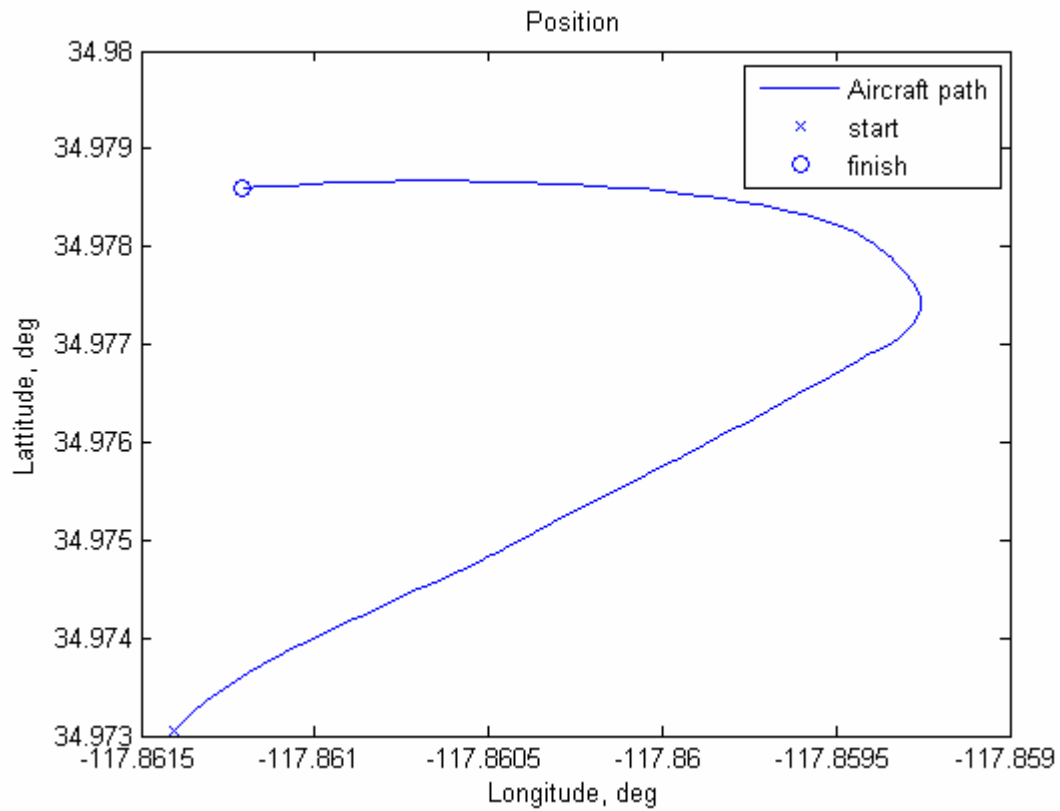


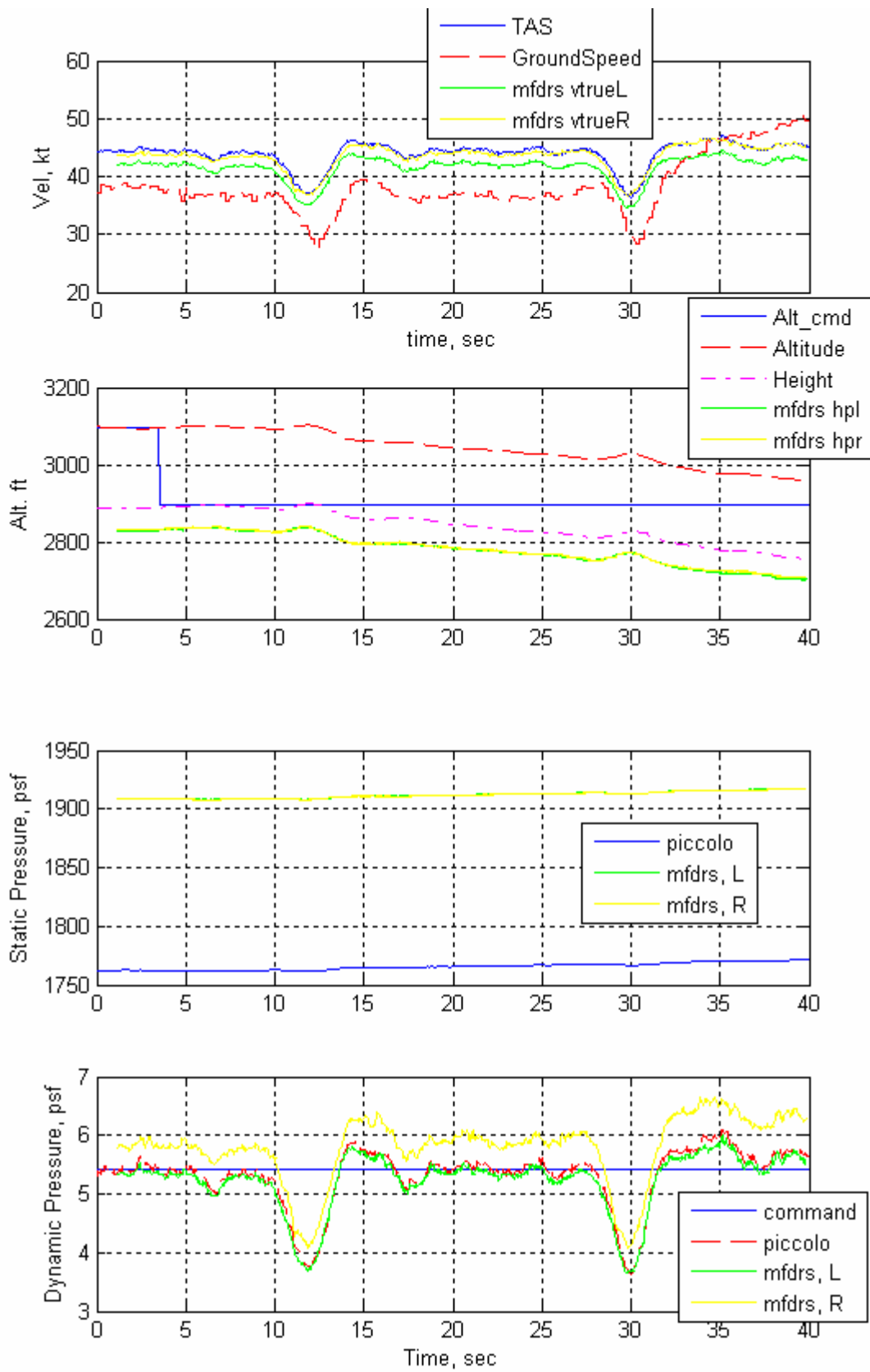


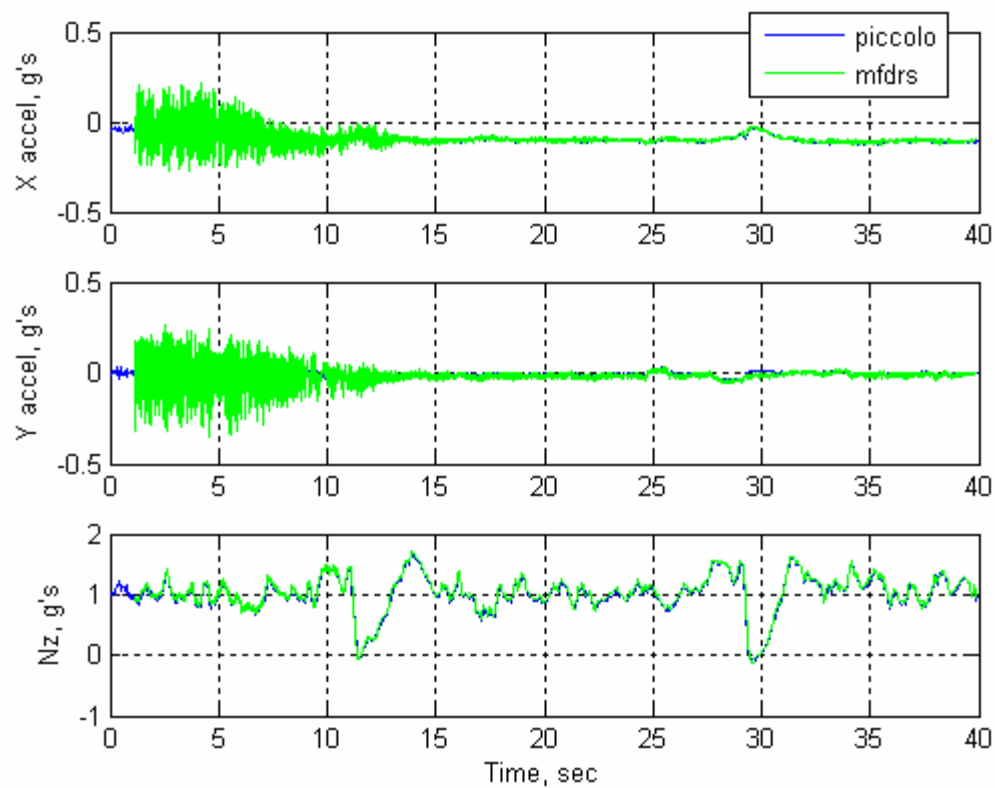
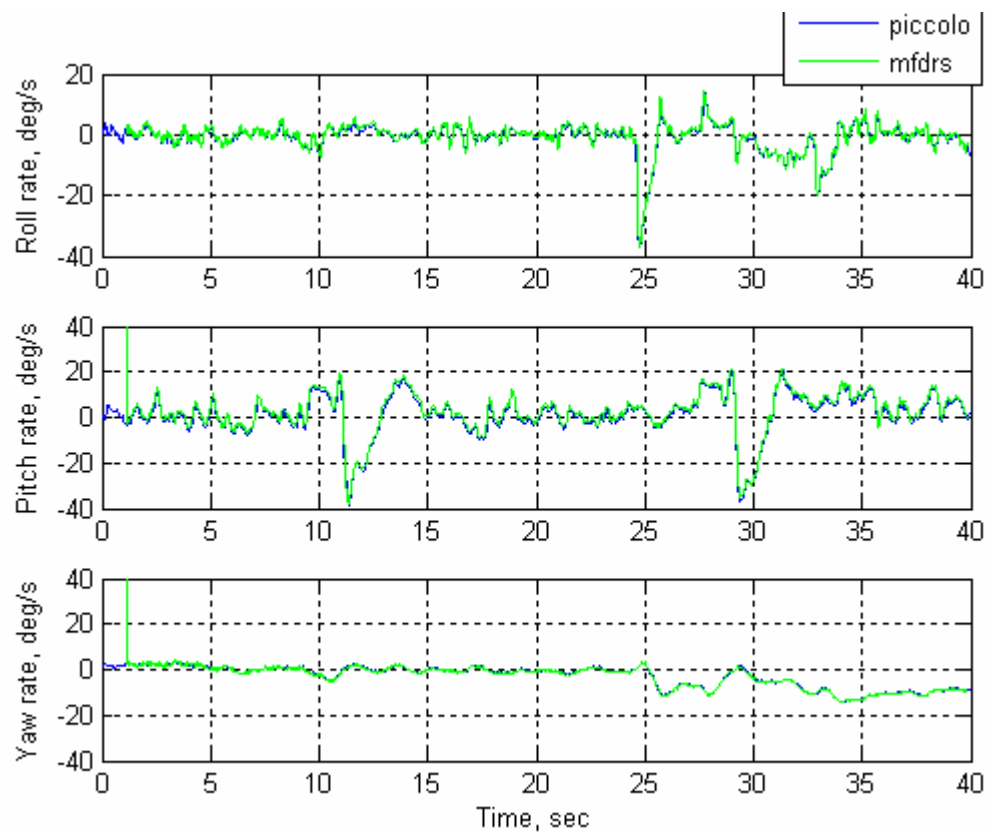


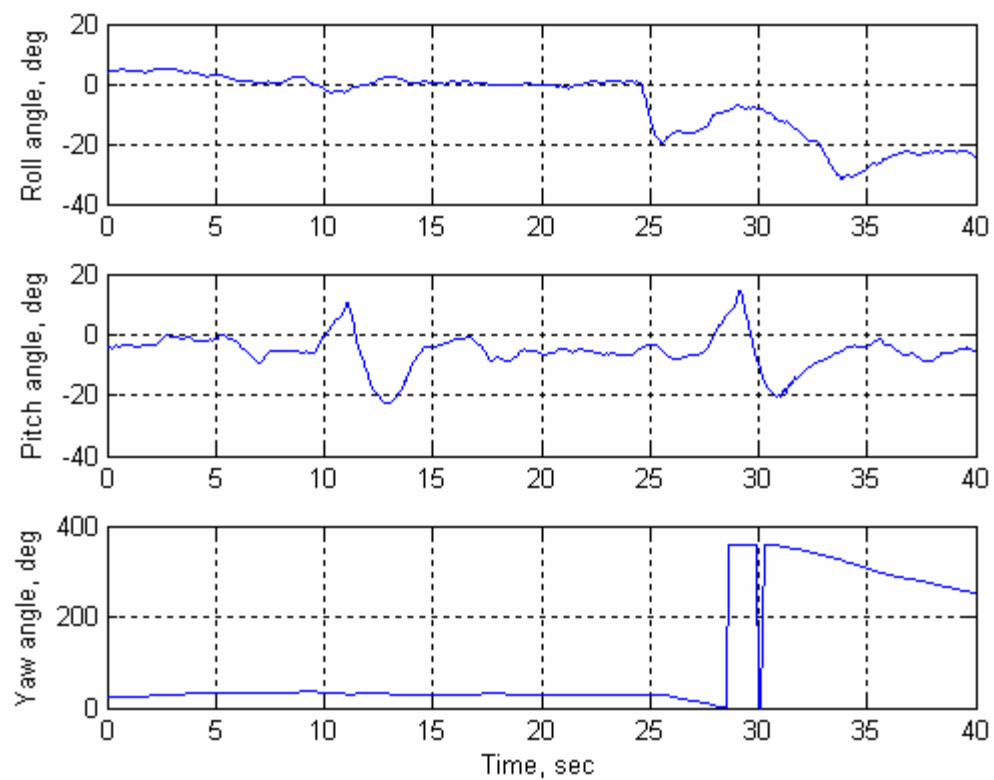
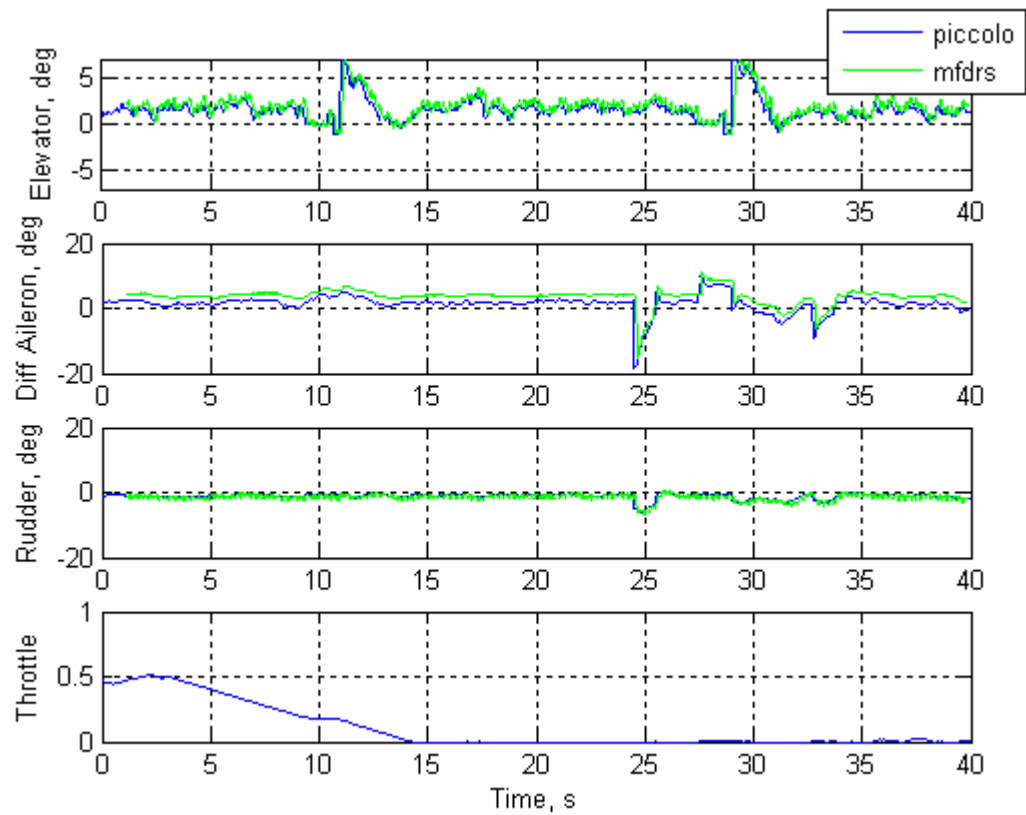
1.4.4 45kt Glide, Long

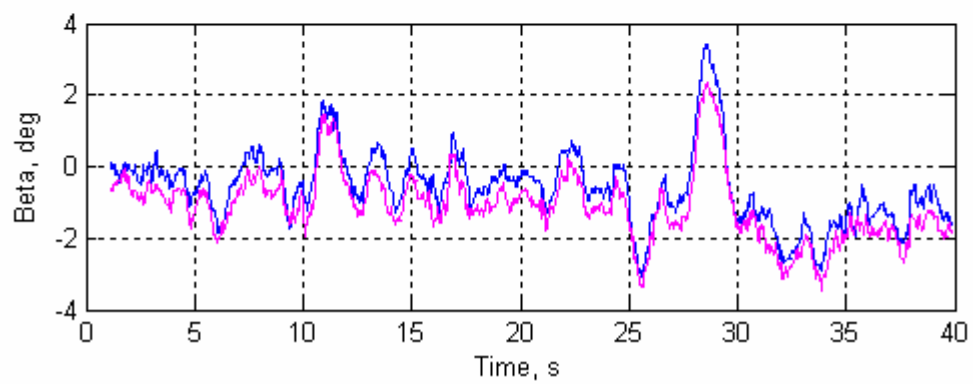
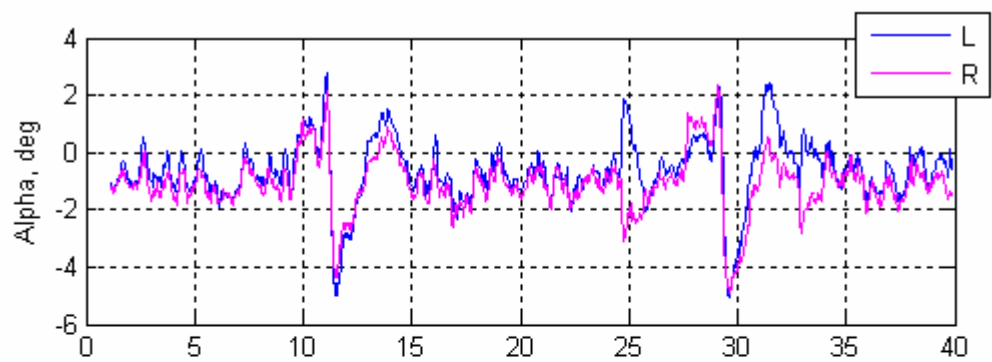
This data includes the entire time that the mfdrs was recording the setup, 45kt glide and setup for the next maneuver. This data included a 45kt glide test, two elevator doublets, and a turn. These maneuvers are broken out into separate files, described later in this document.





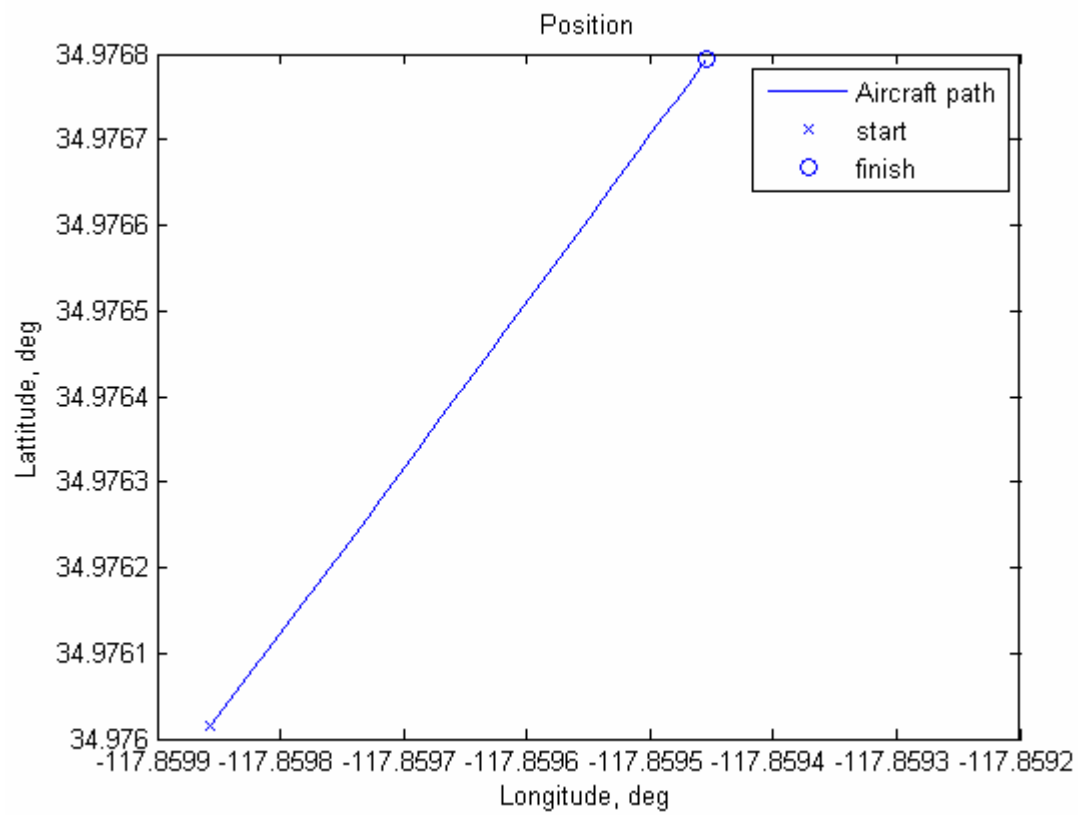


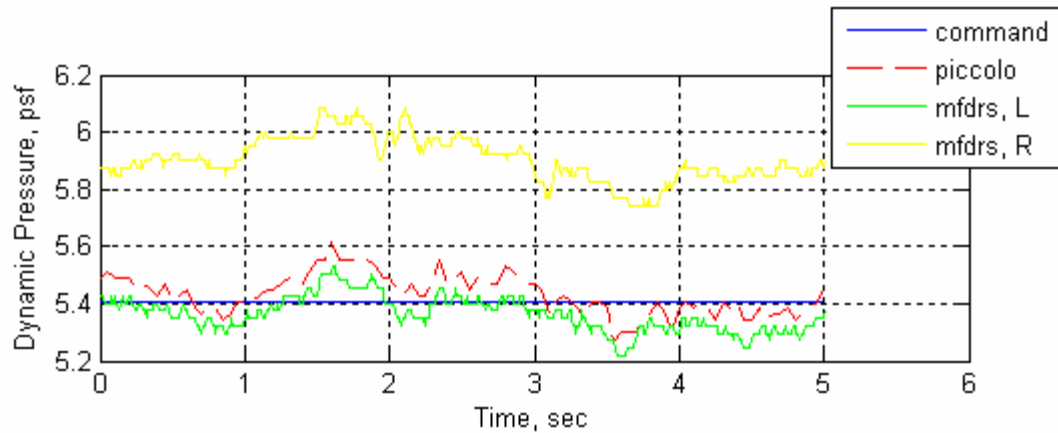
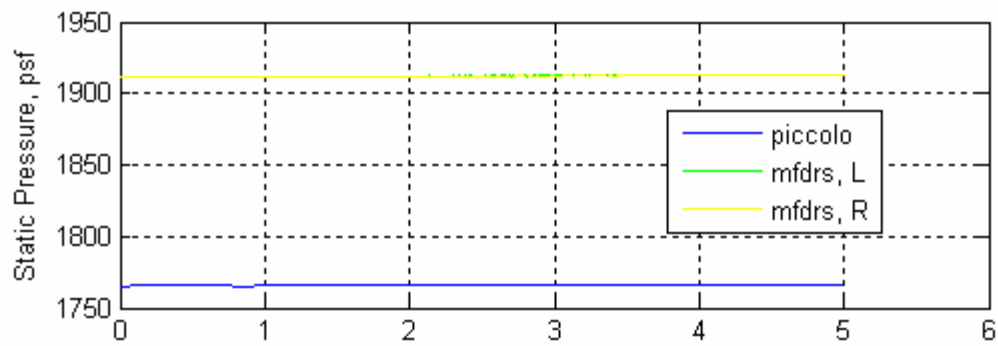
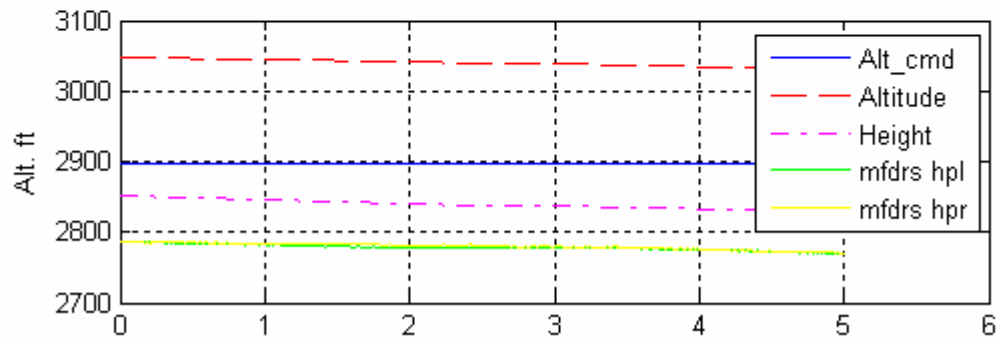
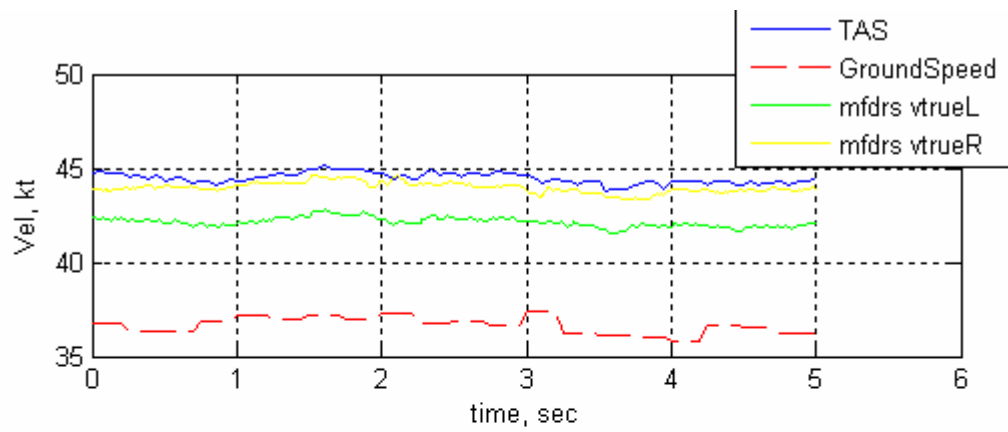


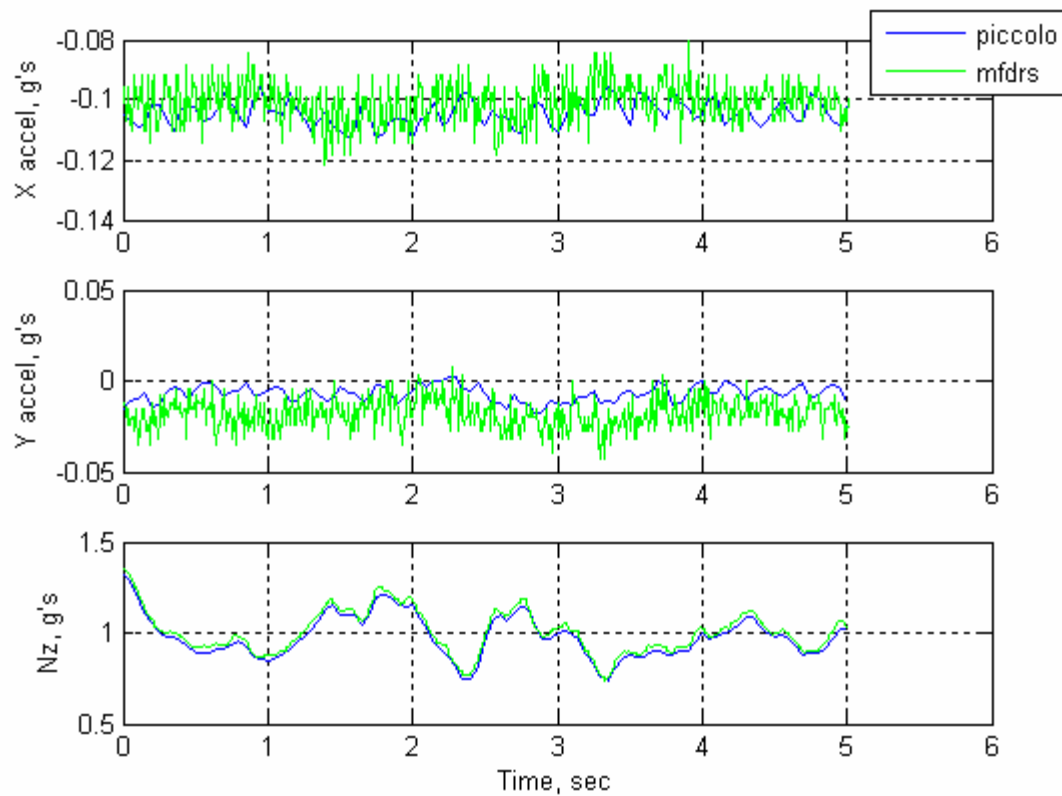
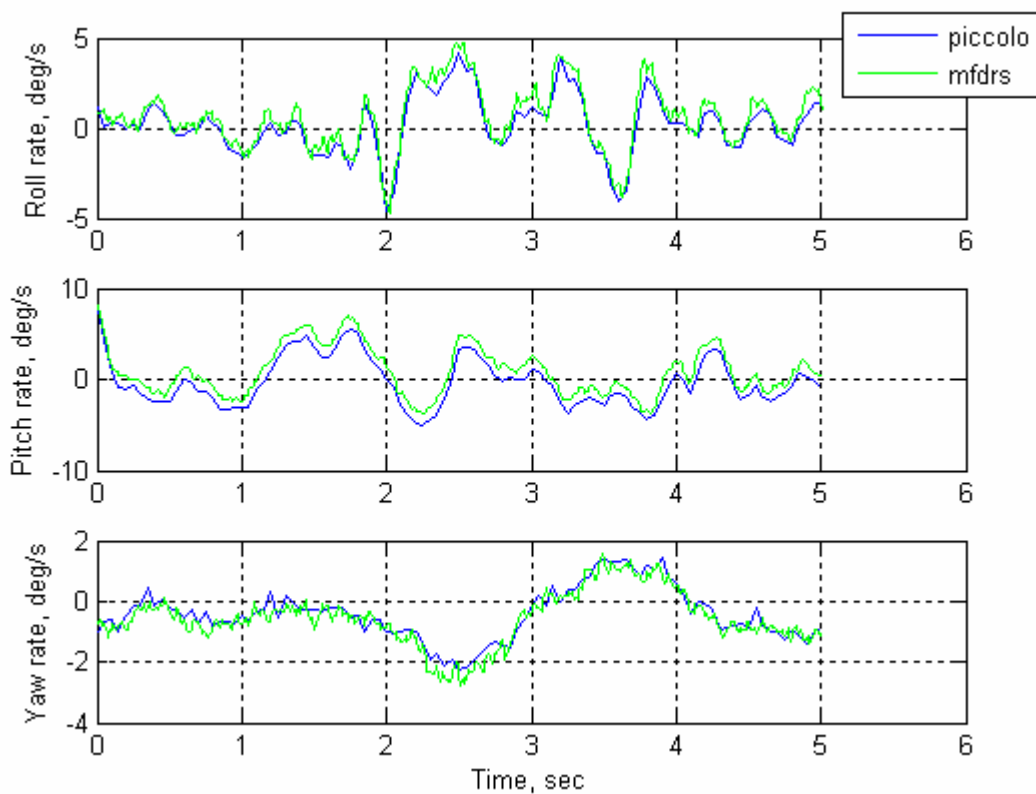


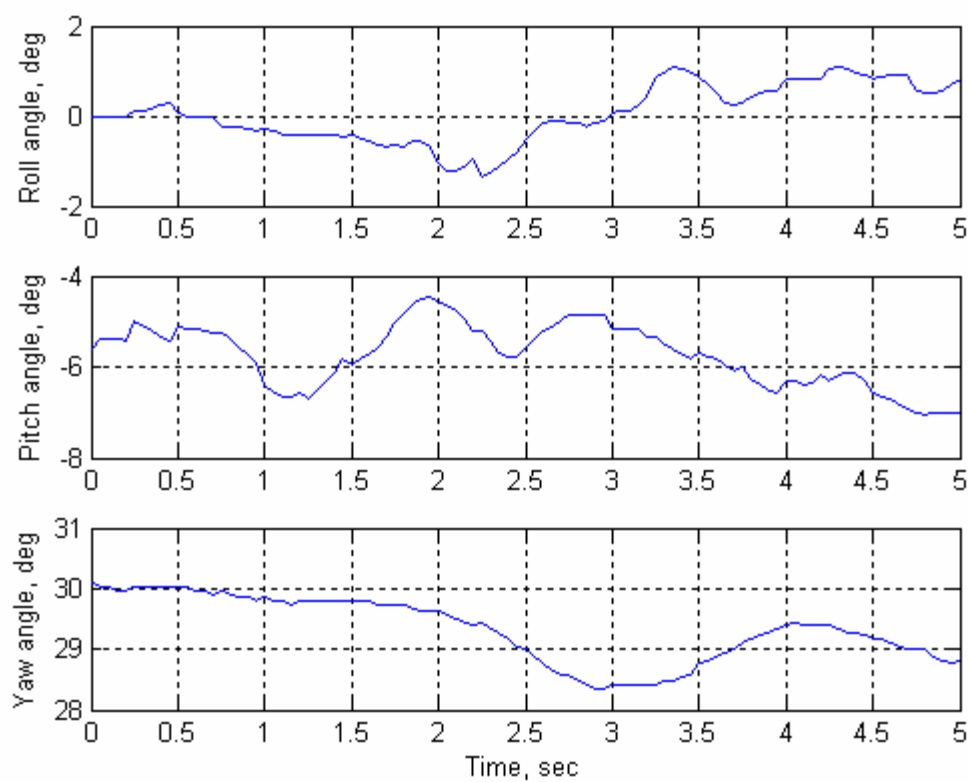
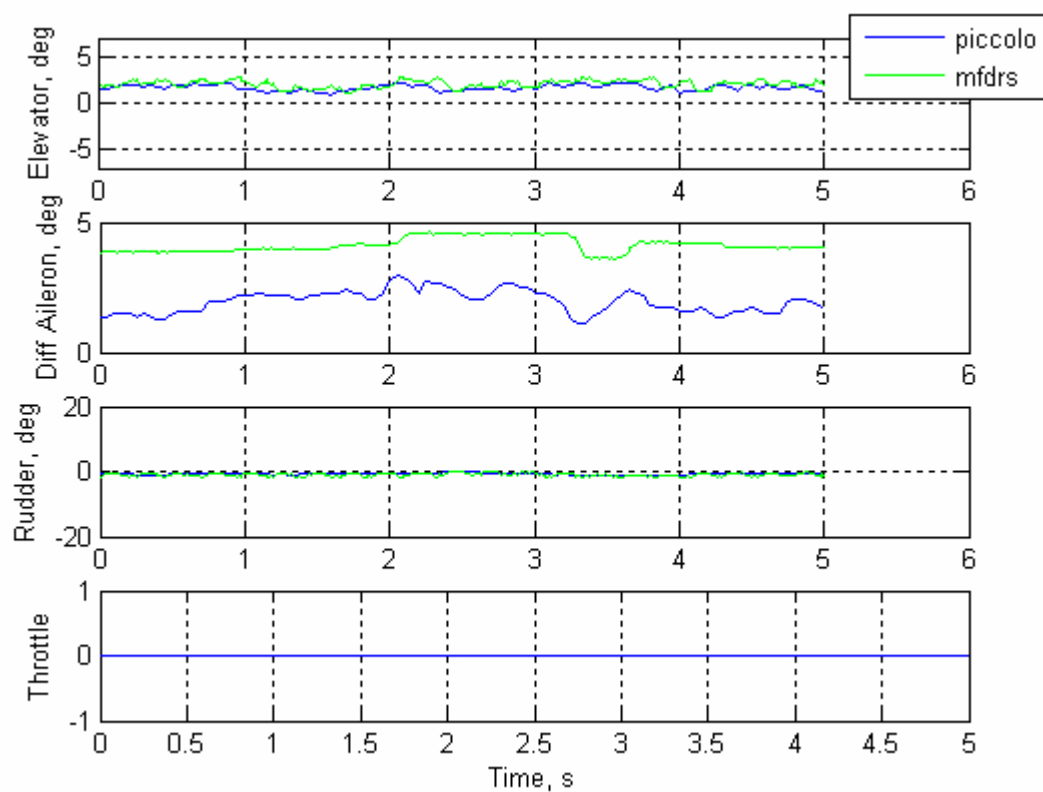
1.4.5 45kt Glide, Short

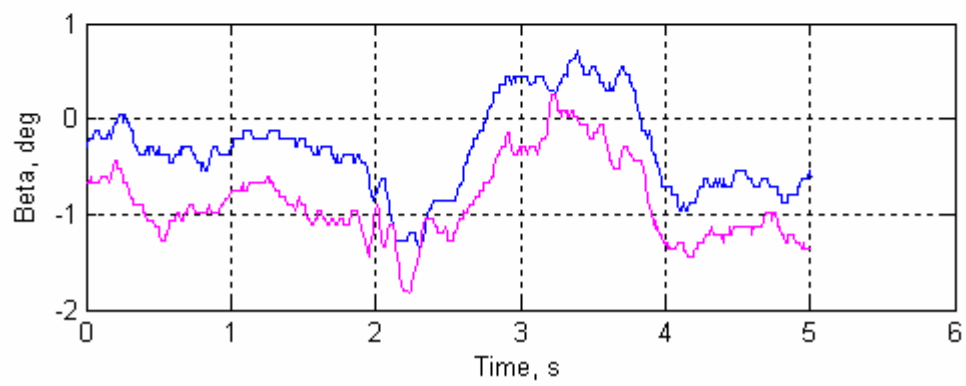
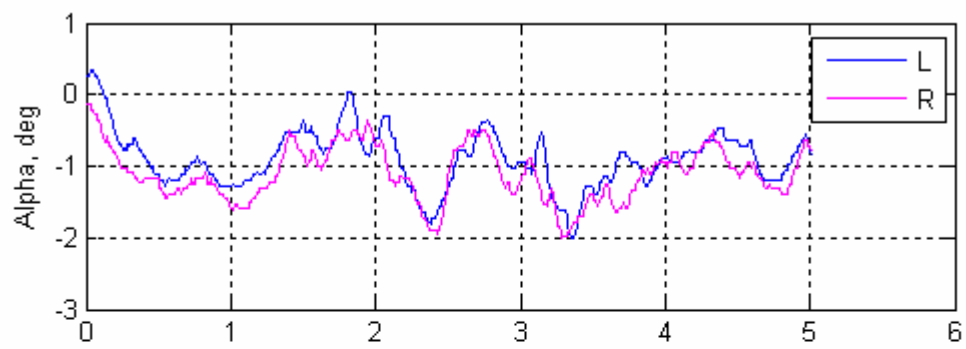
A superb but short maneuver. Zero throttle, calm air.





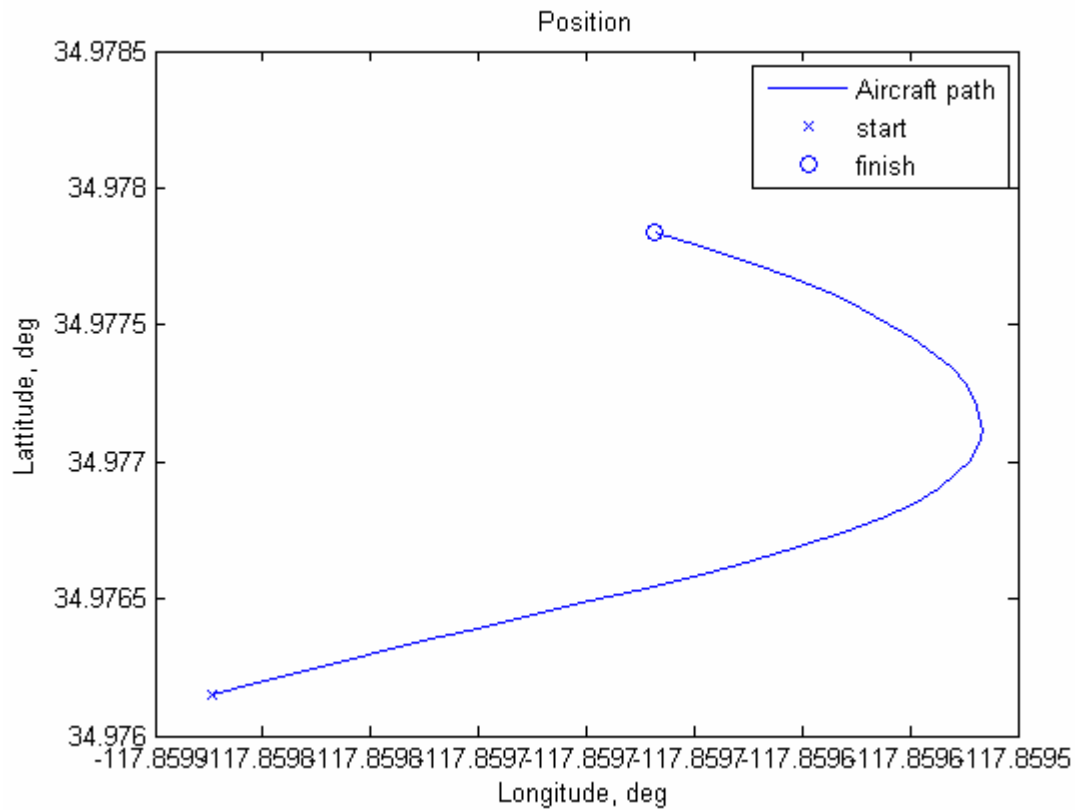


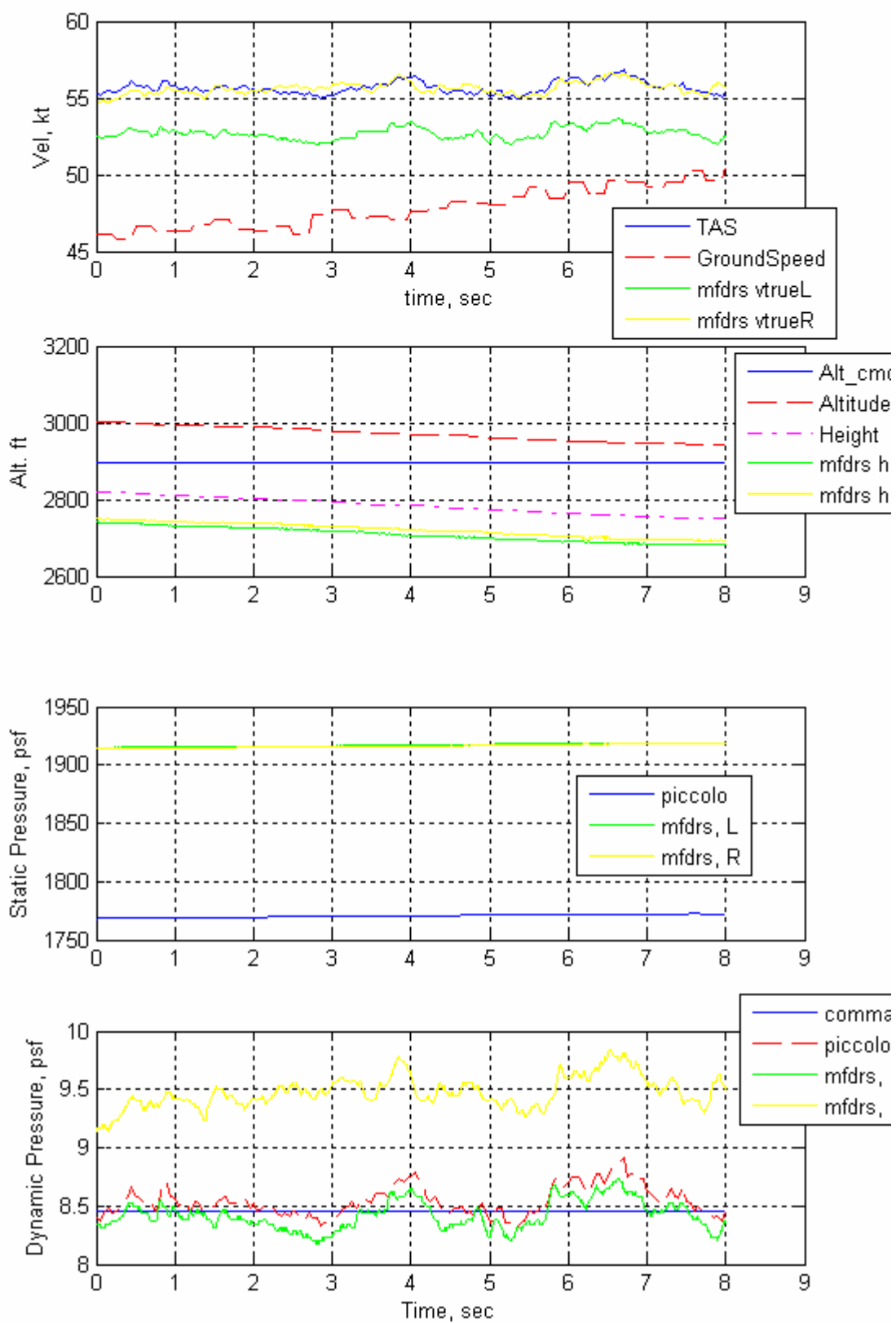


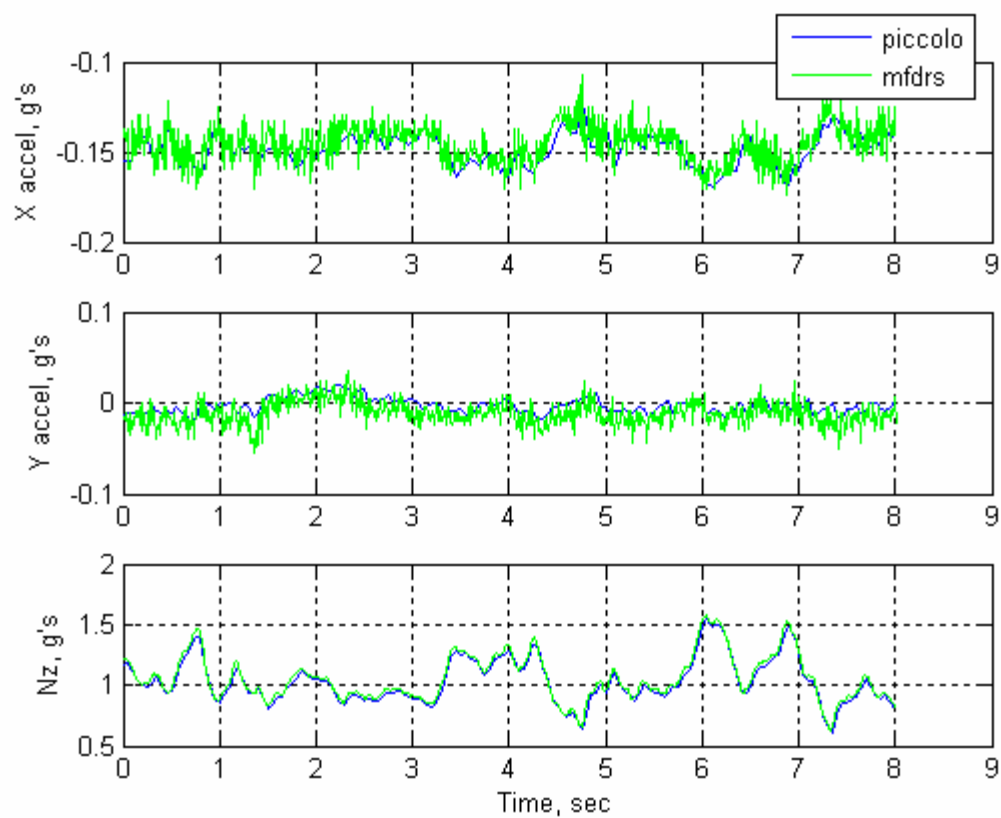
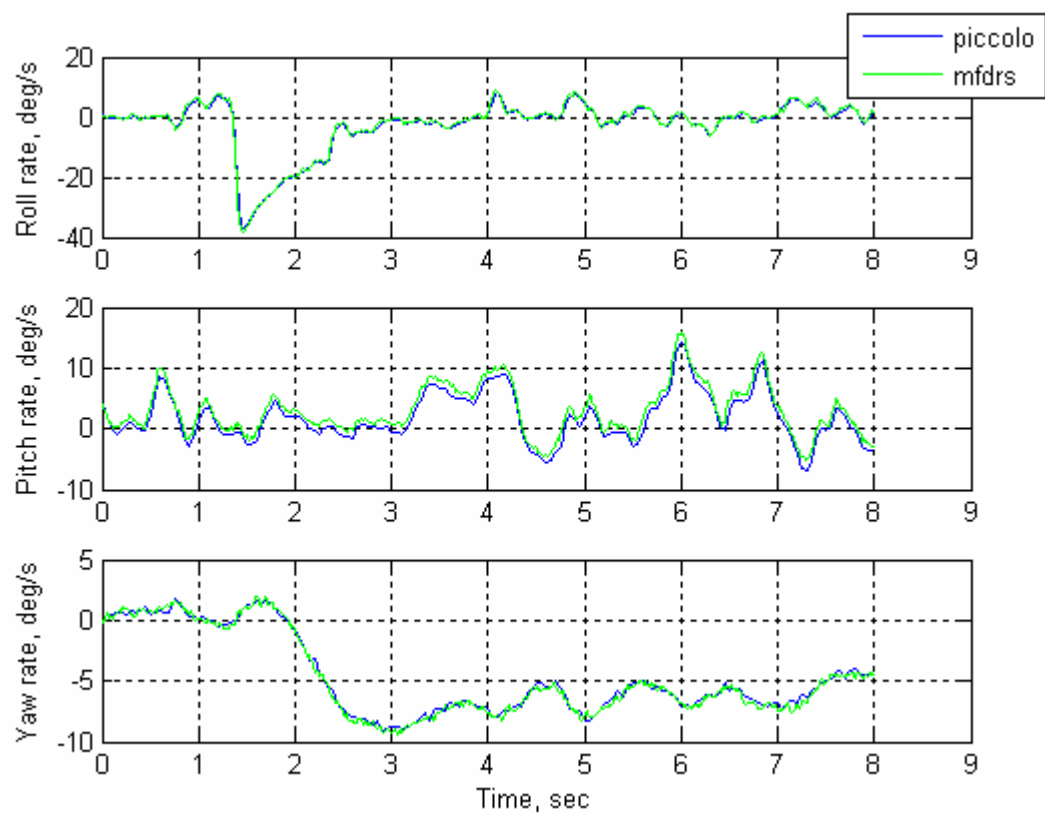


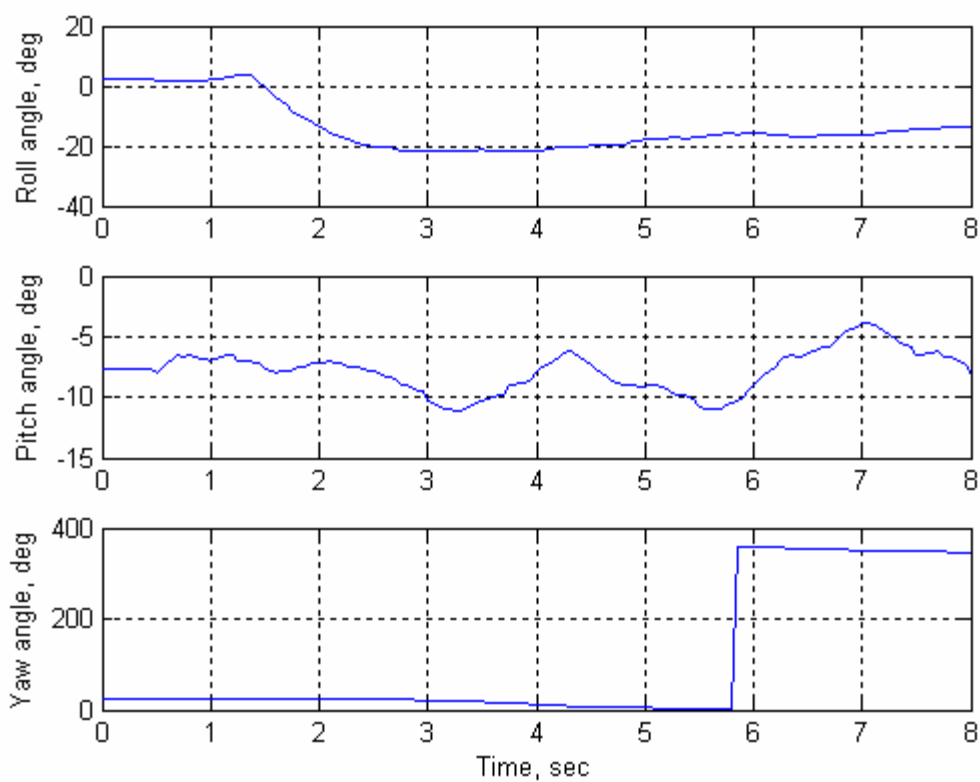
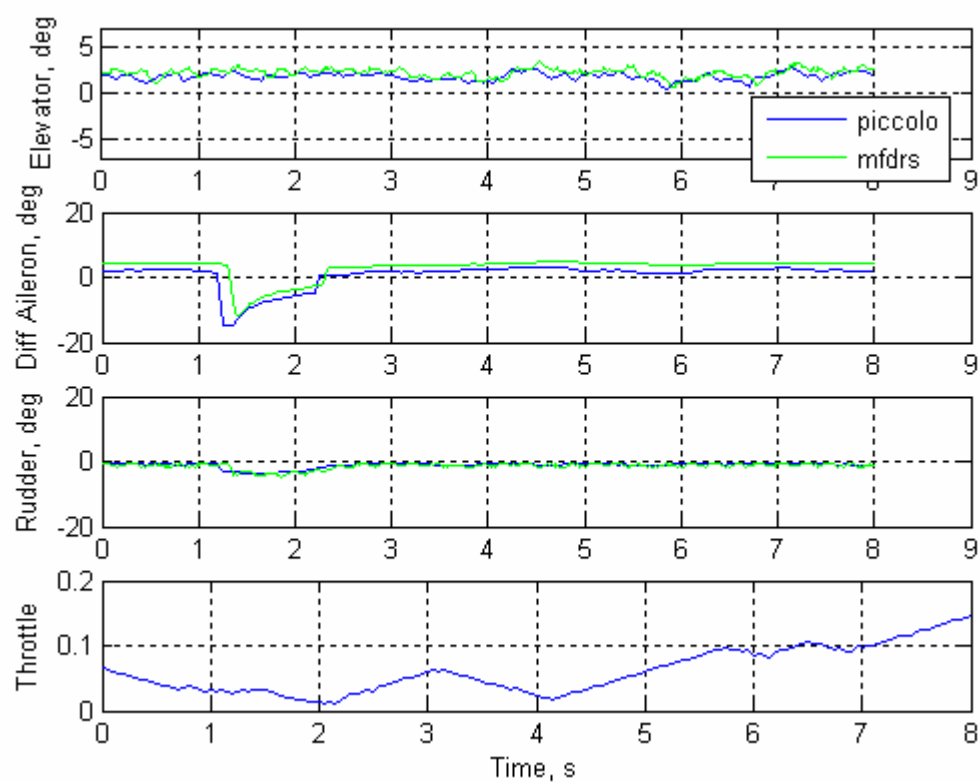
1.4.6 55kt Turn (turn1)

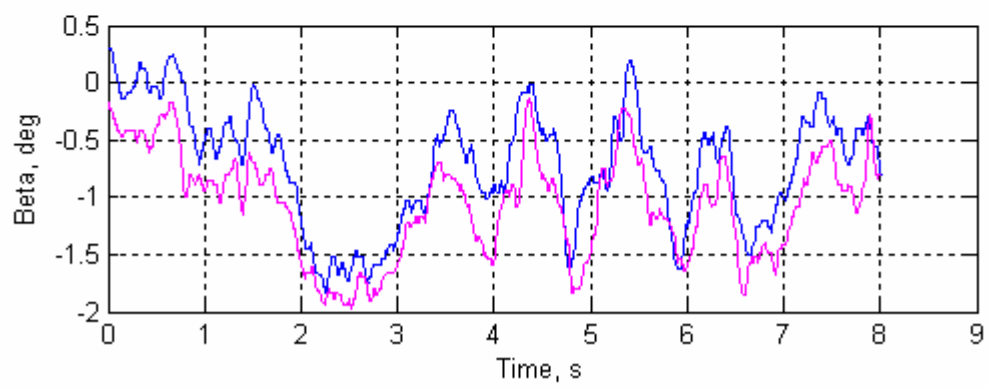
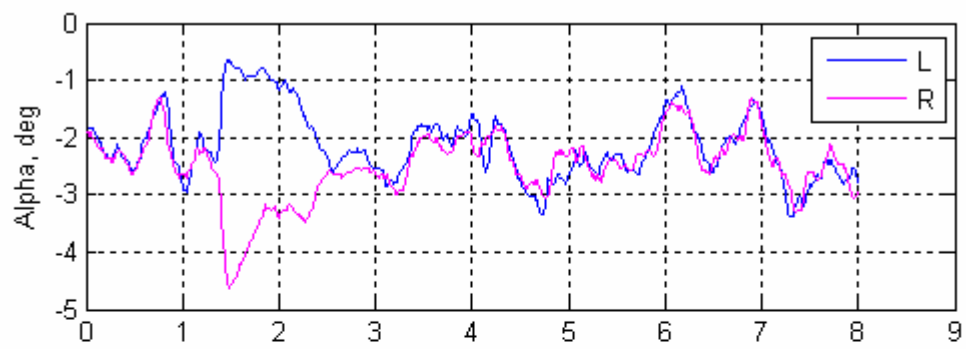
This data may be useful to estimate the lateral/directional derivatives of the Cloud Swift. The data was taken during the 55kt glide test. Throttle was never zero but it was less than 10%. Aileron and Rudder are coupled for this maneuver so it is of limited use for PID. Note the angle of attack difference during the roll due to the probe locations out on the wing.





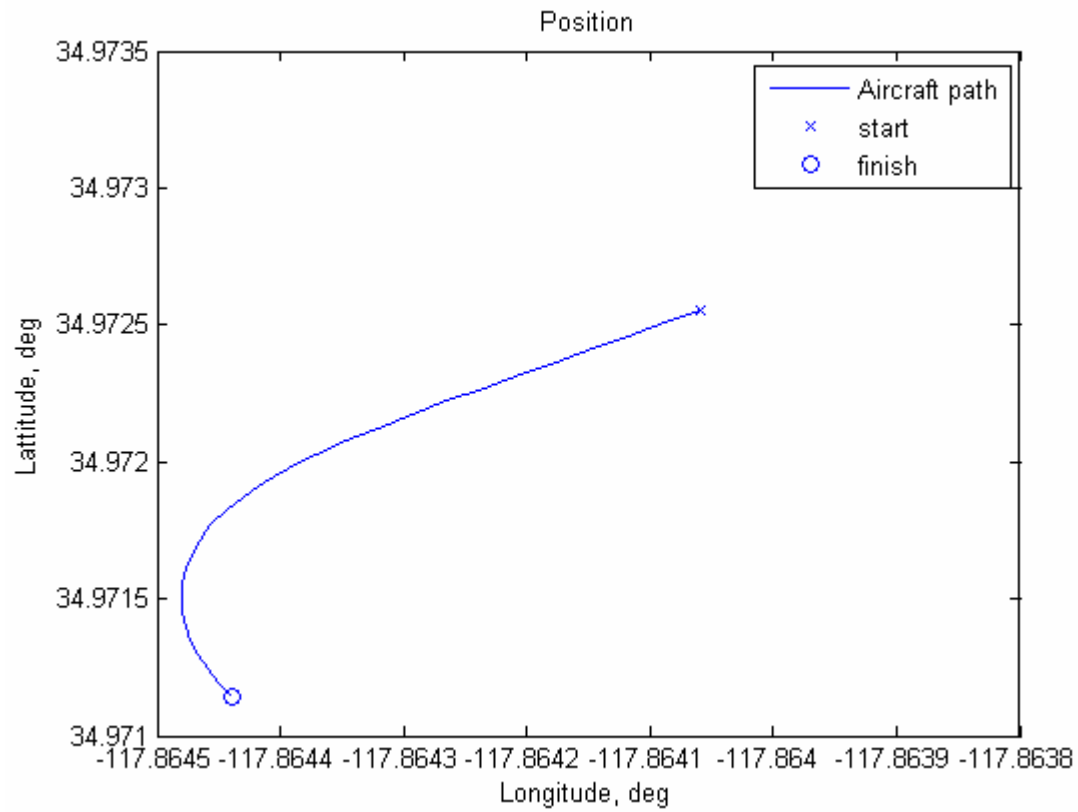


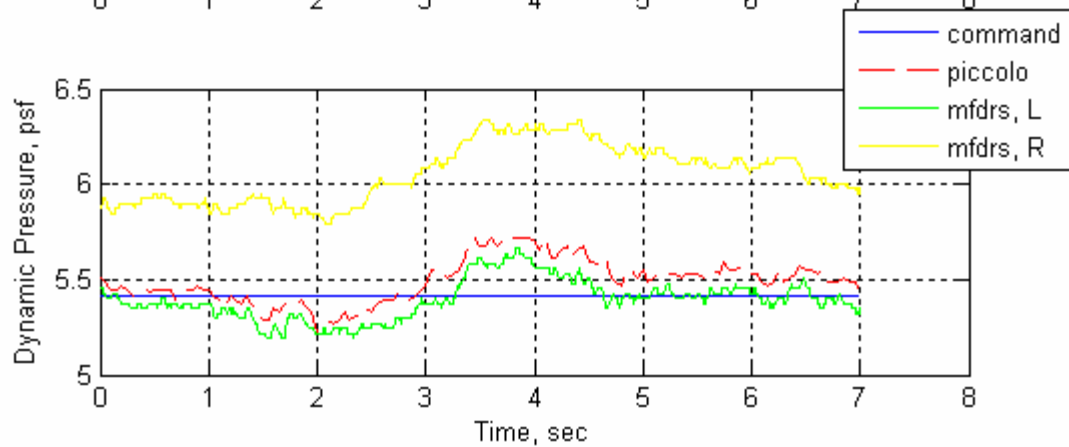
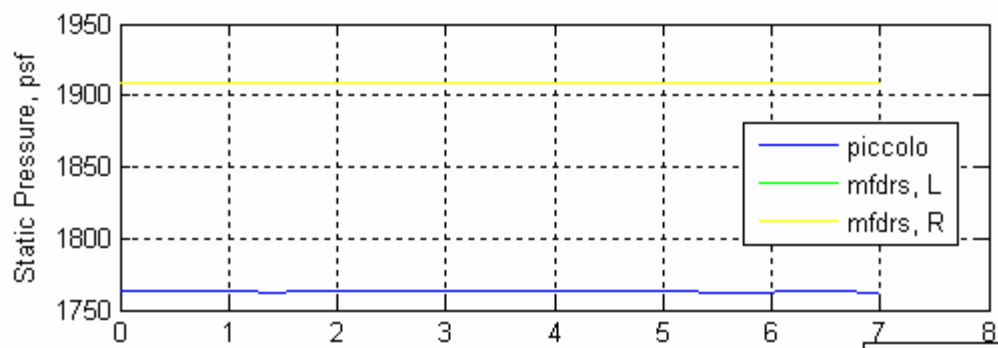
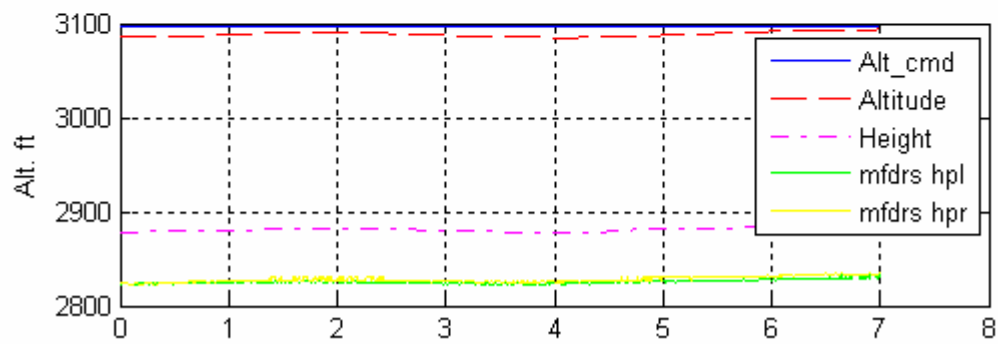
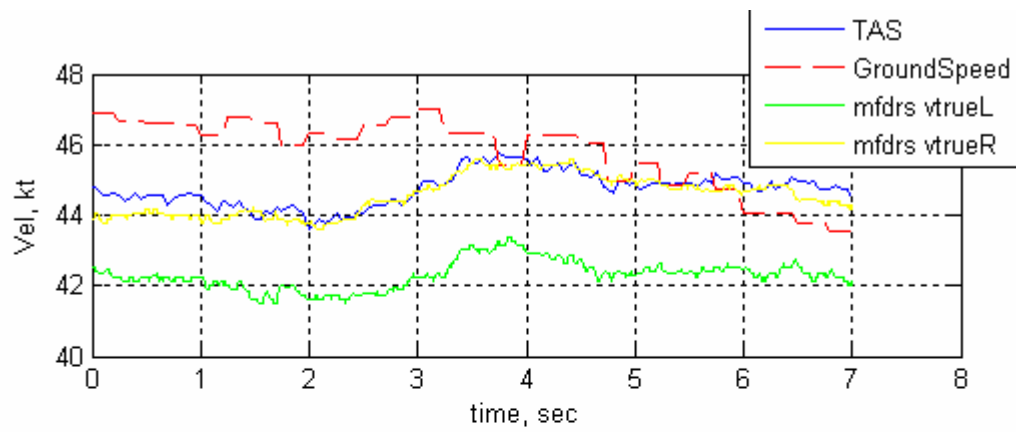


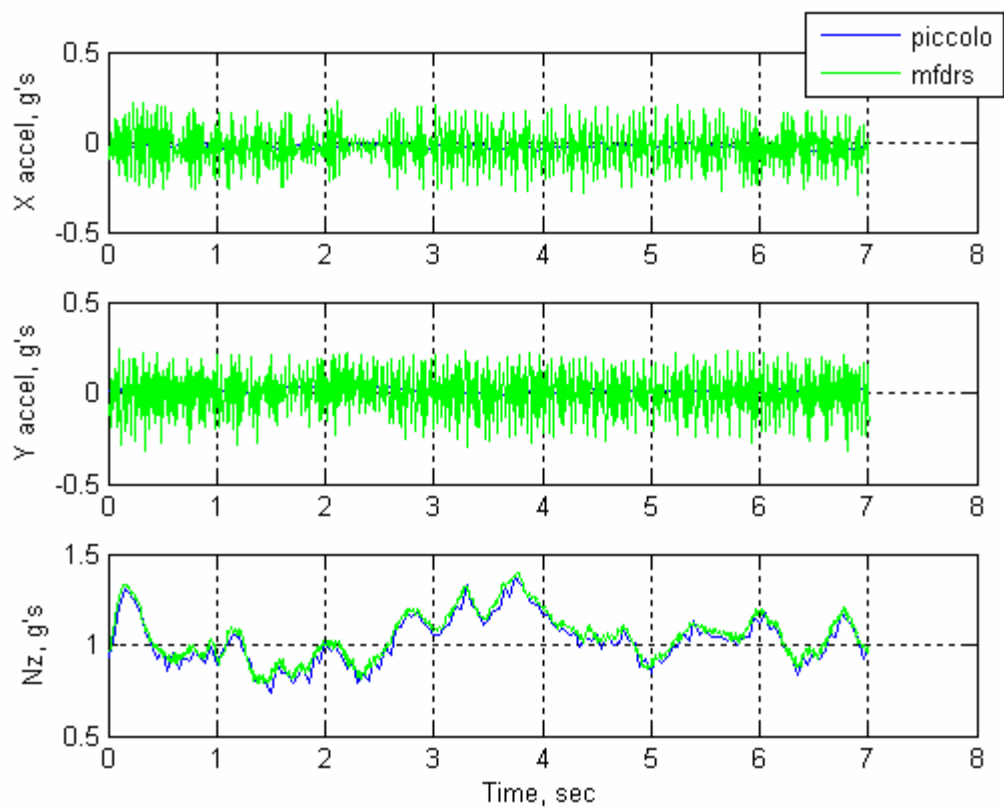
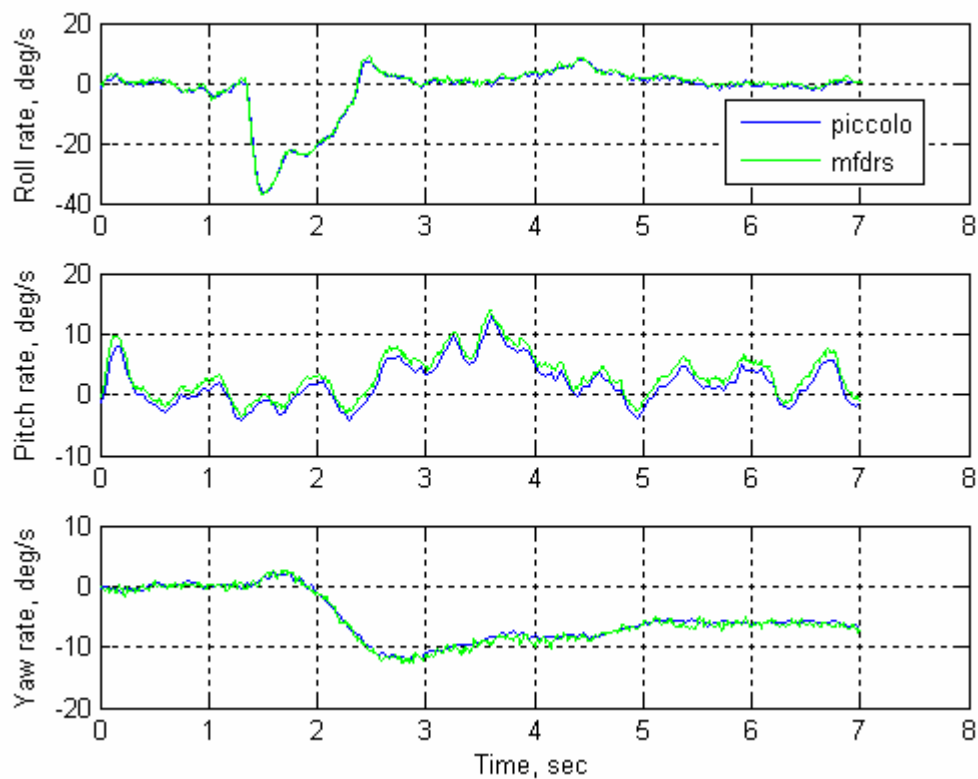


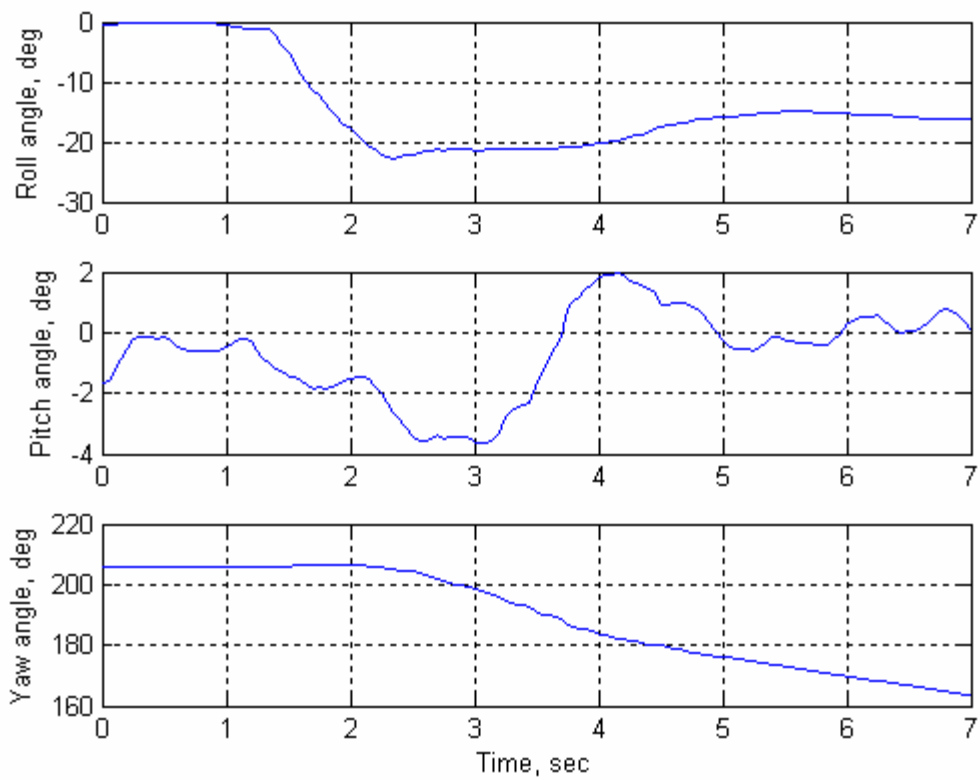
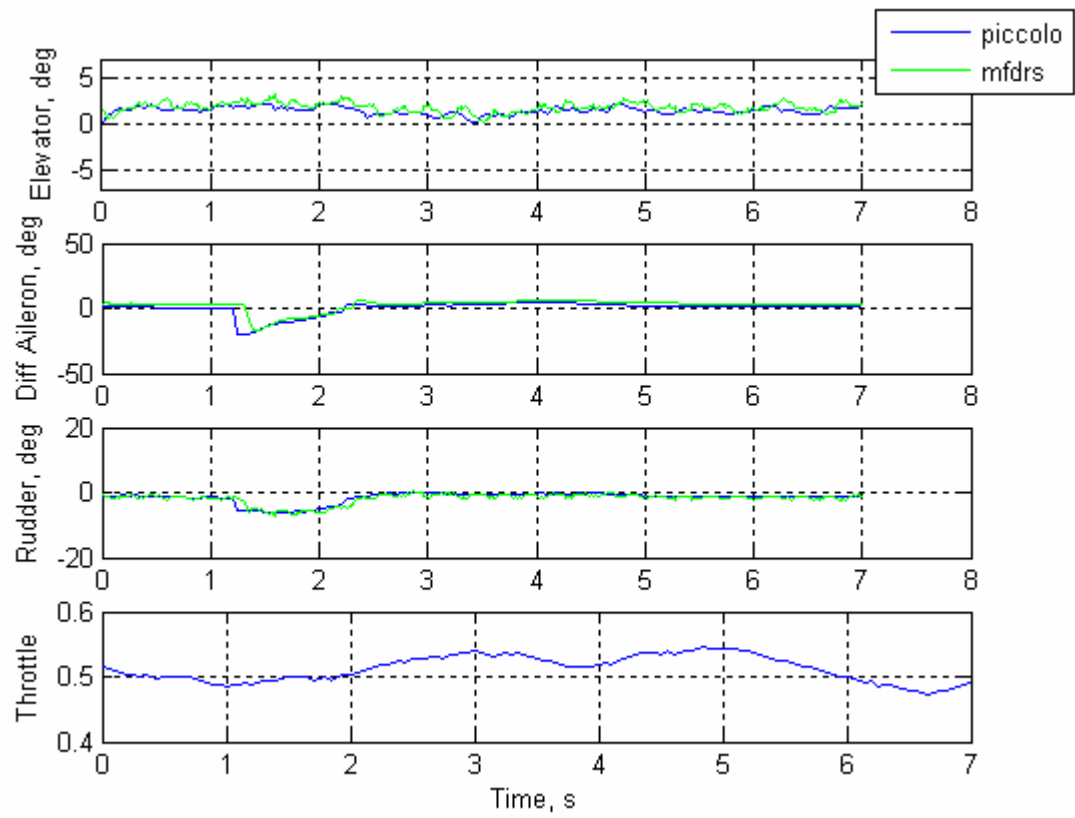
1.4.7 45kt Turn (turn2)

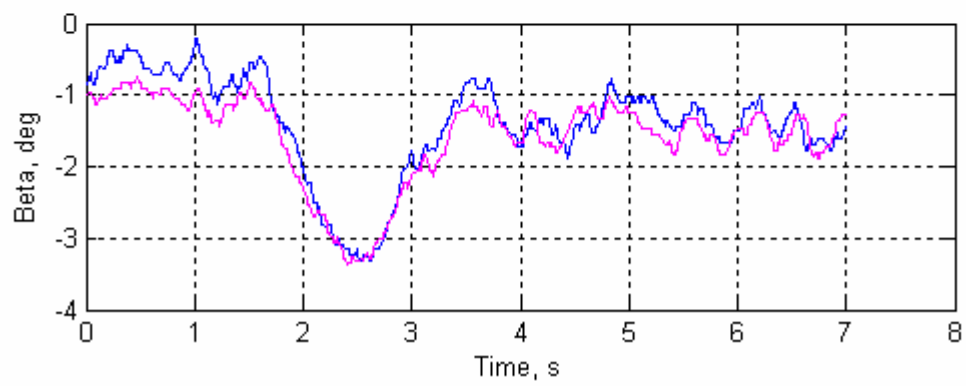
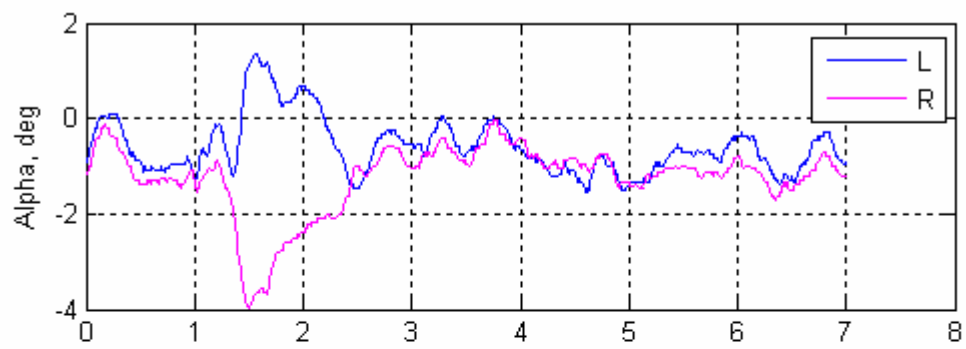
Data for this turn came from the 55kt speed run during setup for the next glide at 45kt. Throttle is not zero.



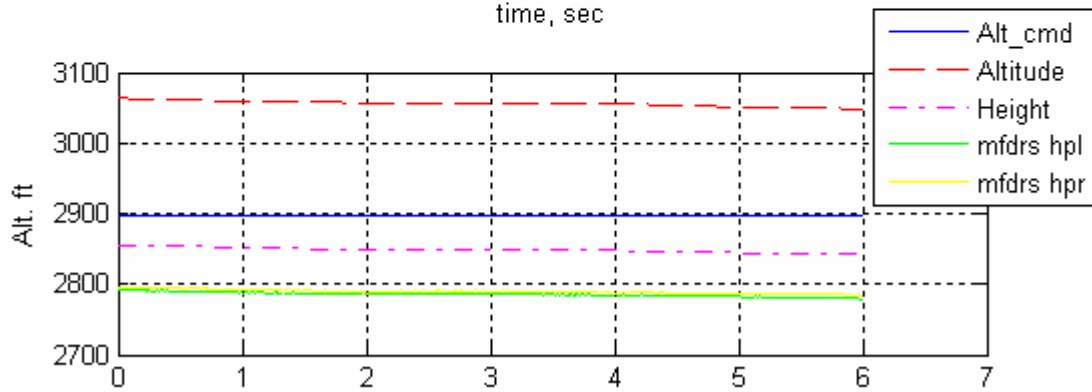
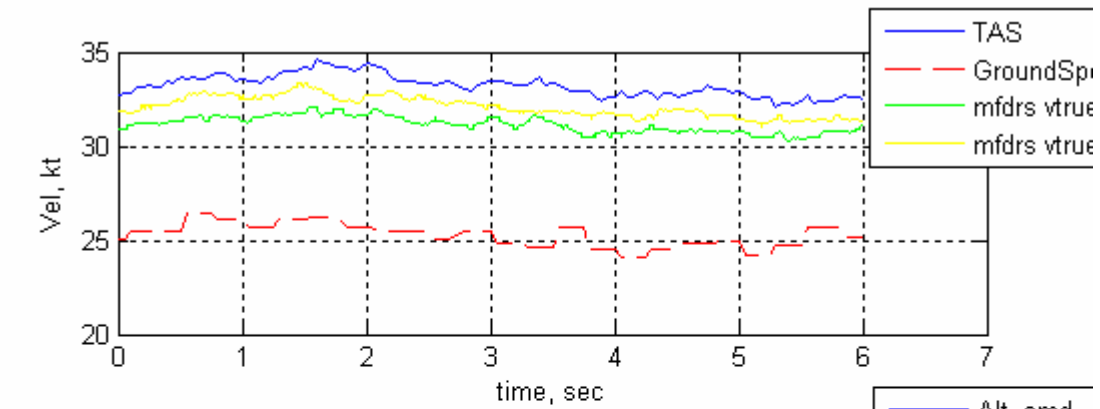
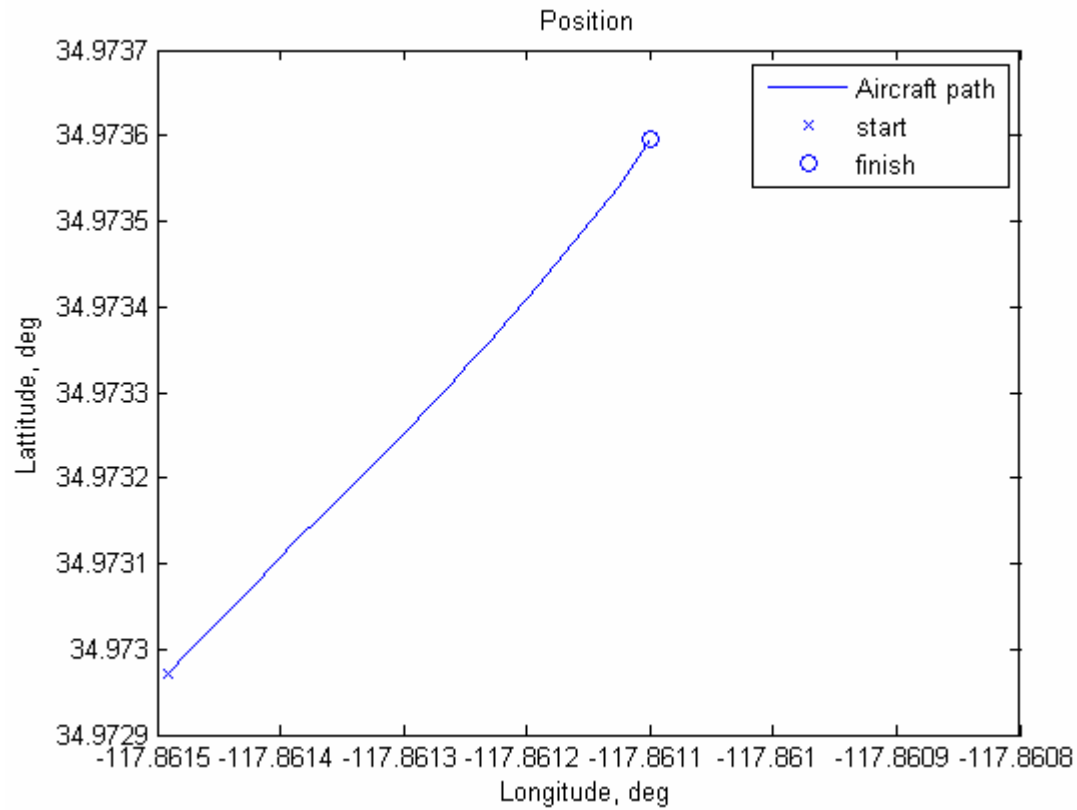


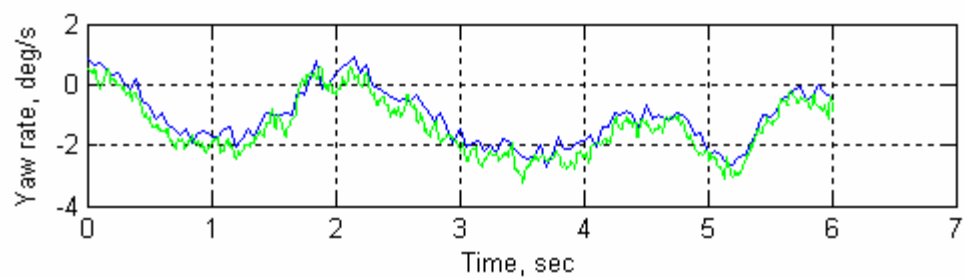
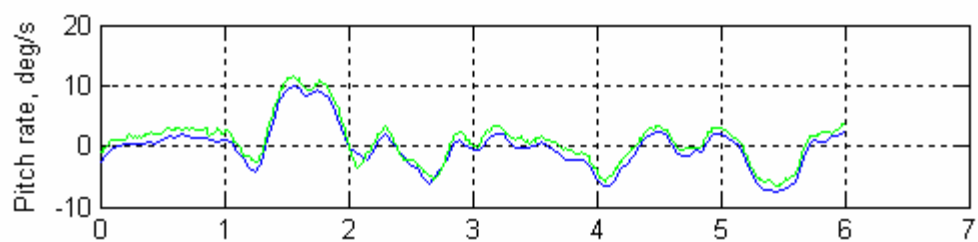
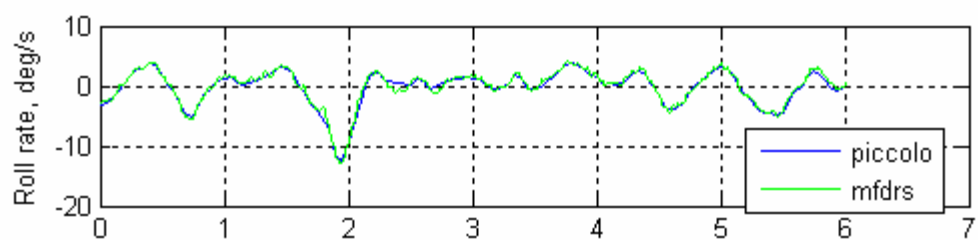
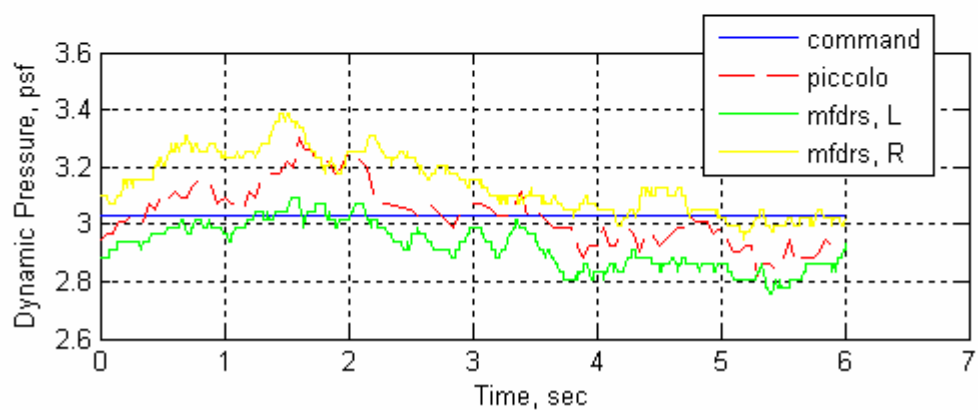
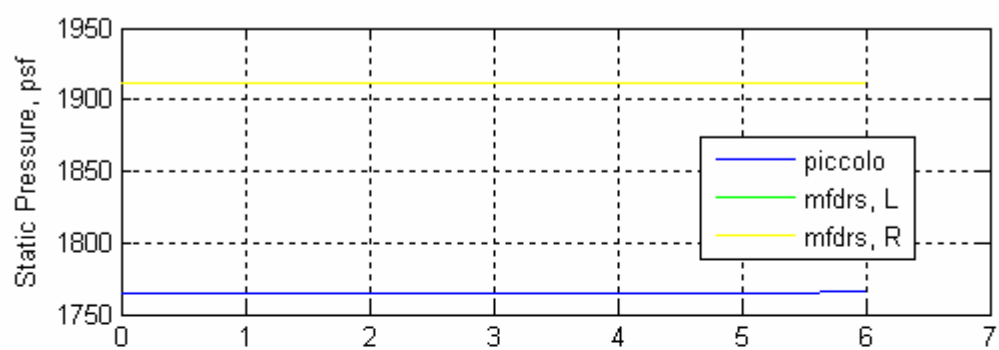


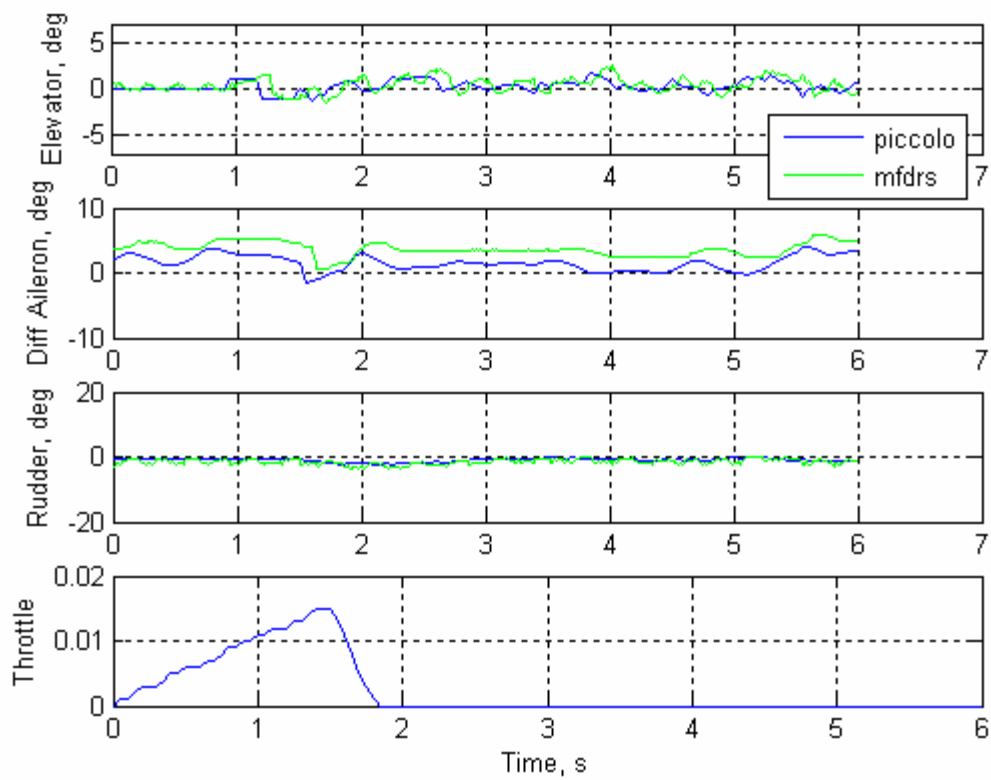
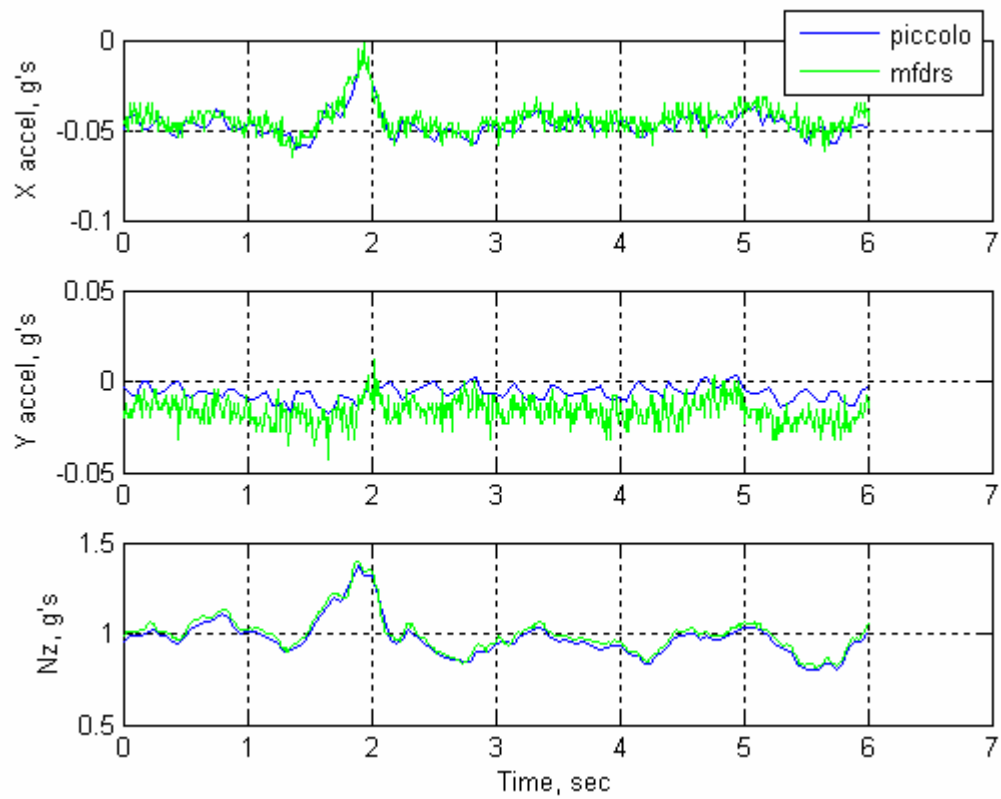


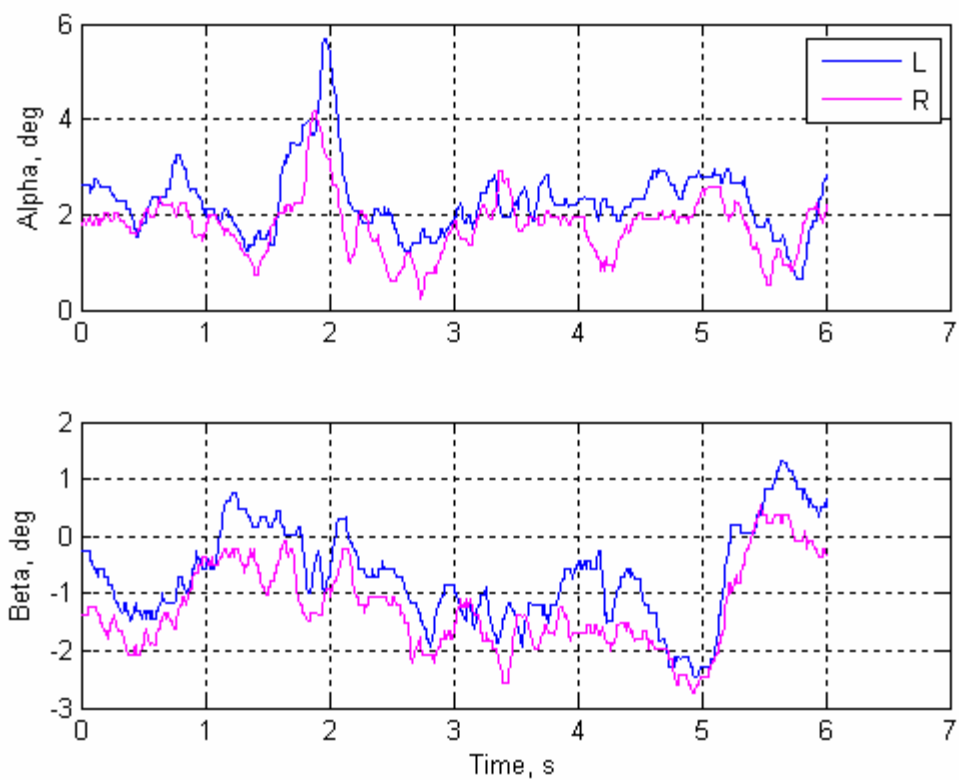
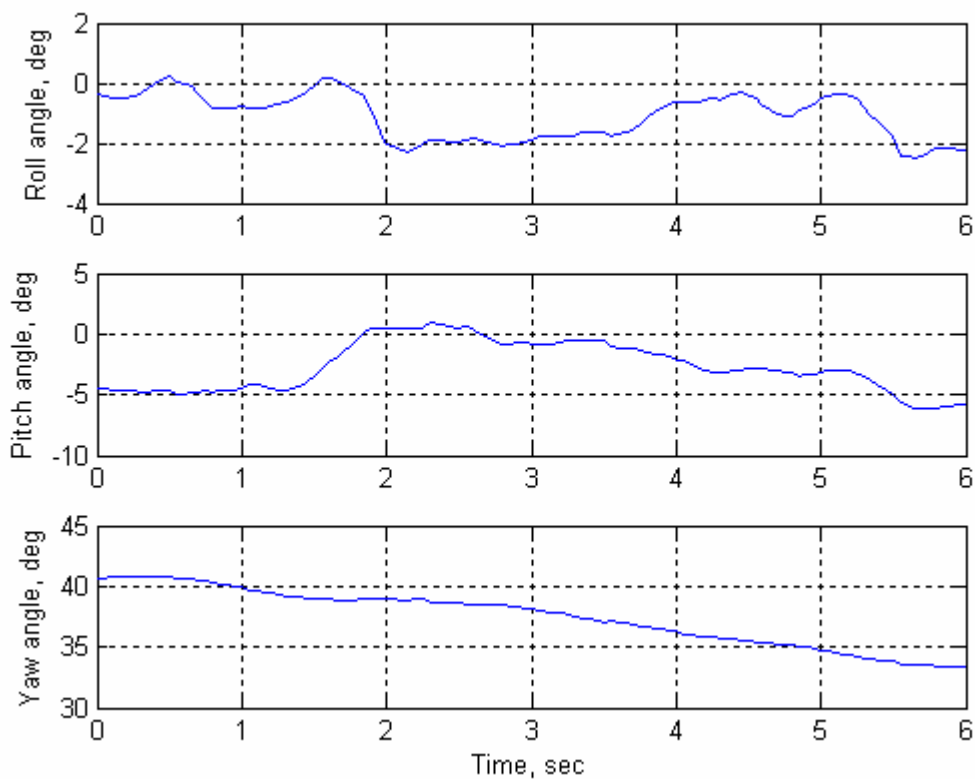


1.4.8 Elevator Doublet 1 (35kt)



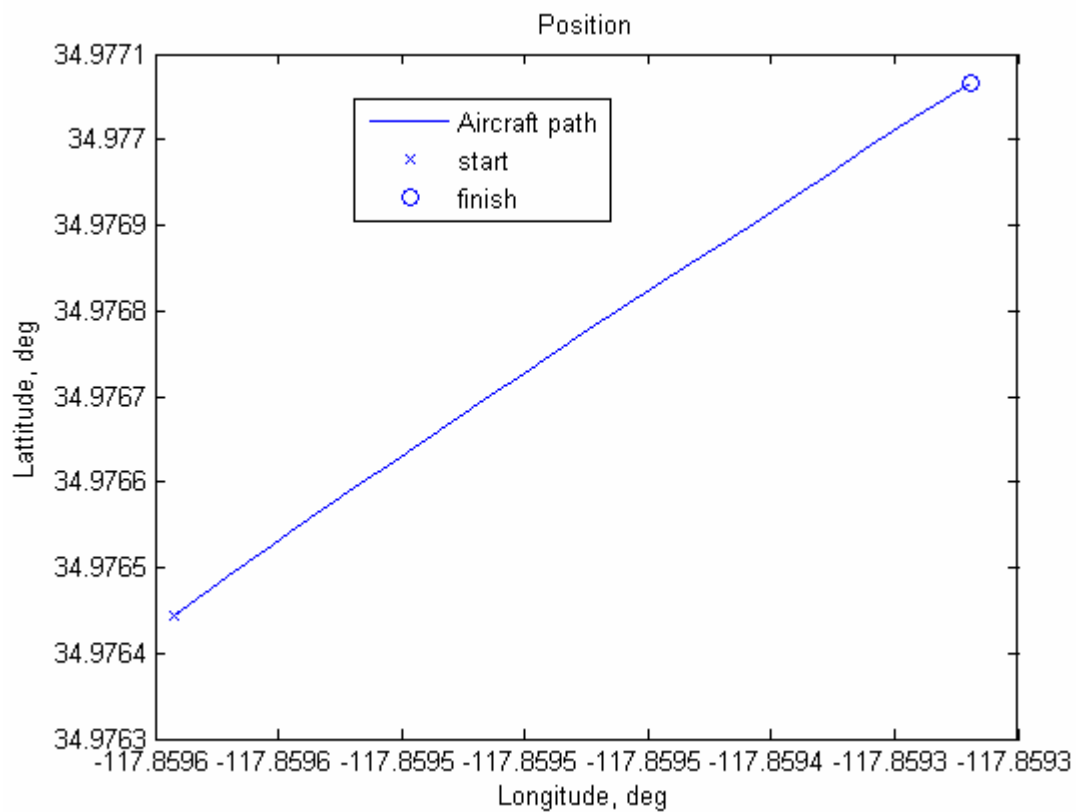


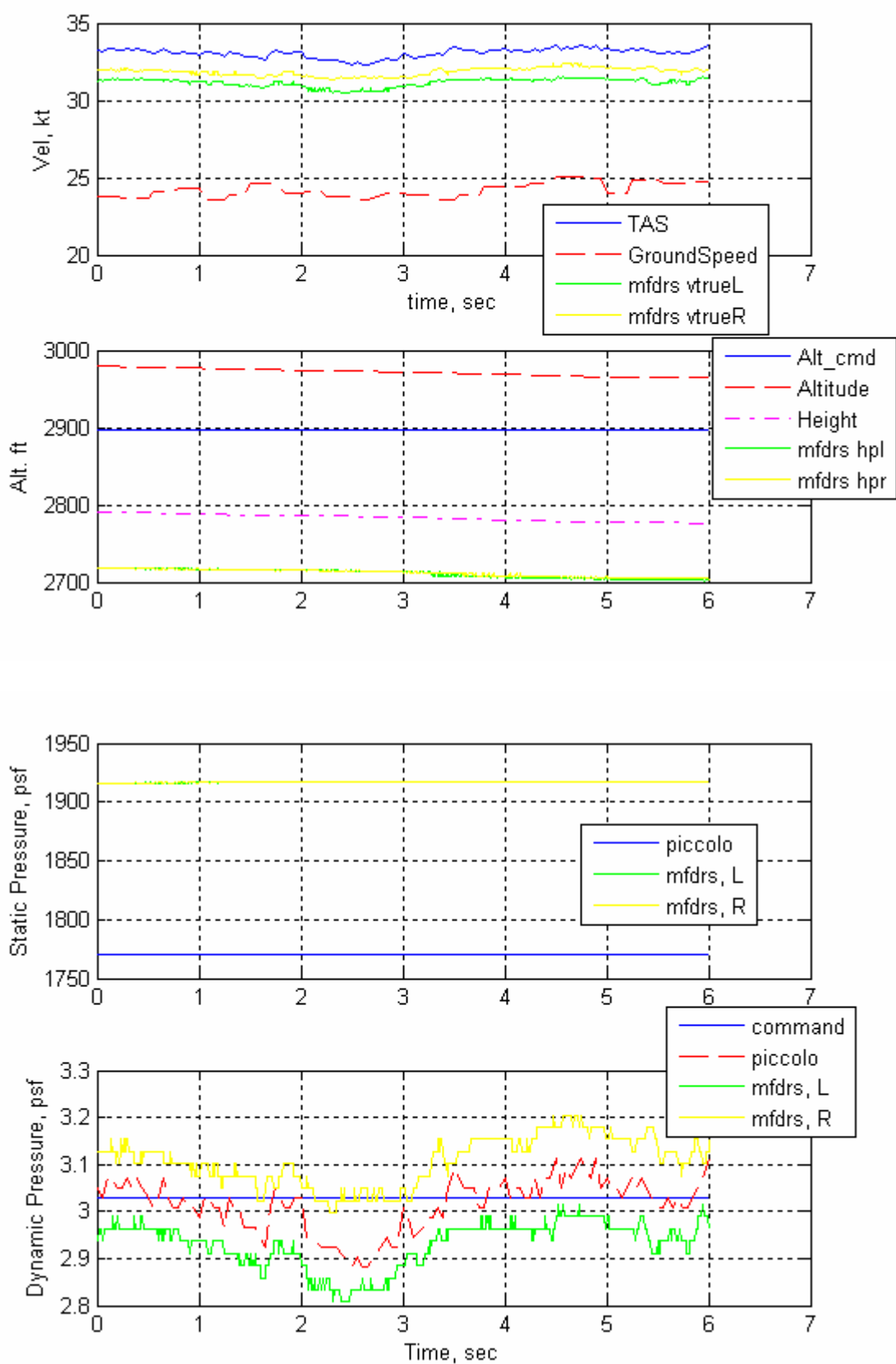


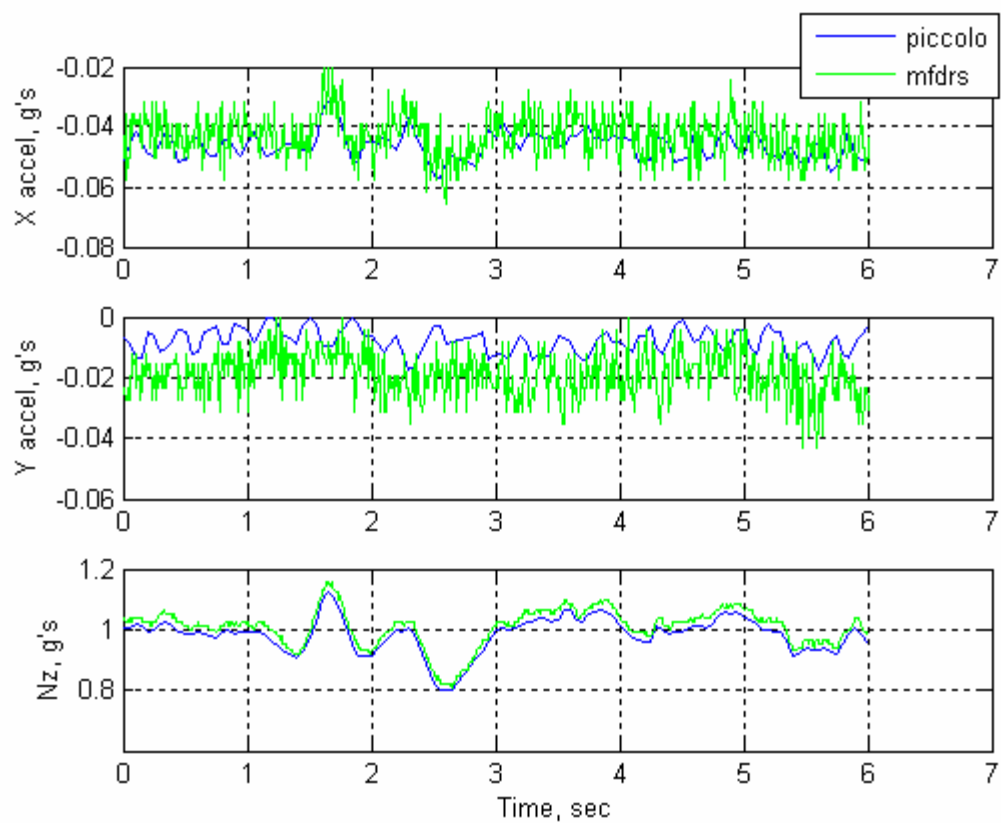
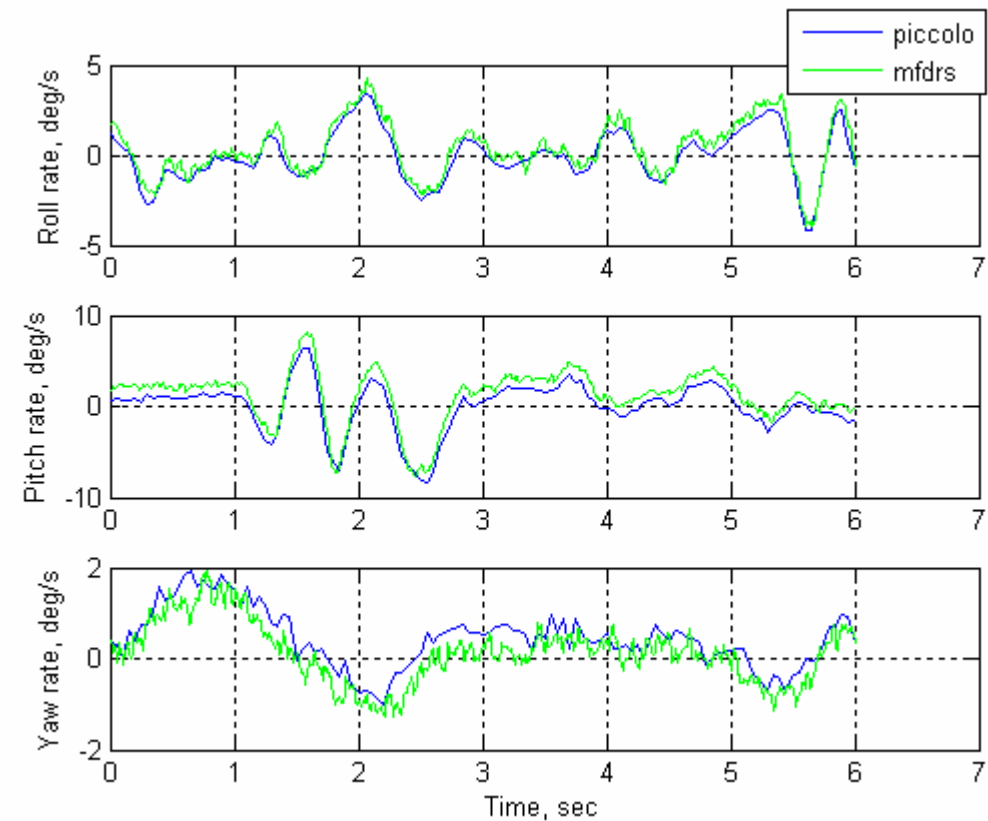


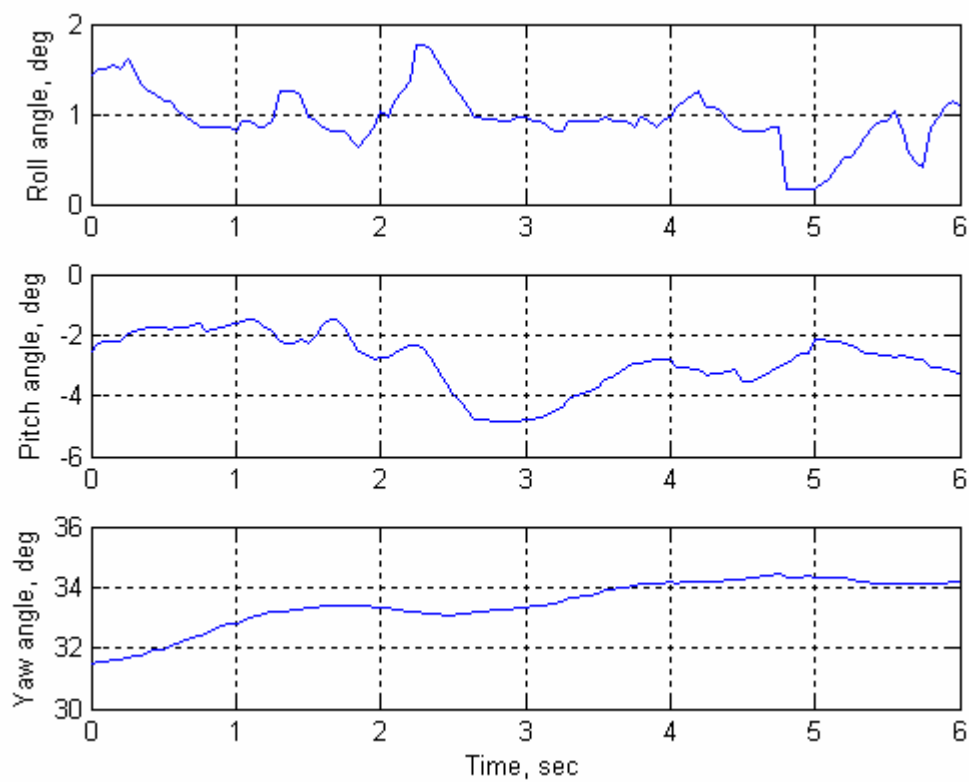
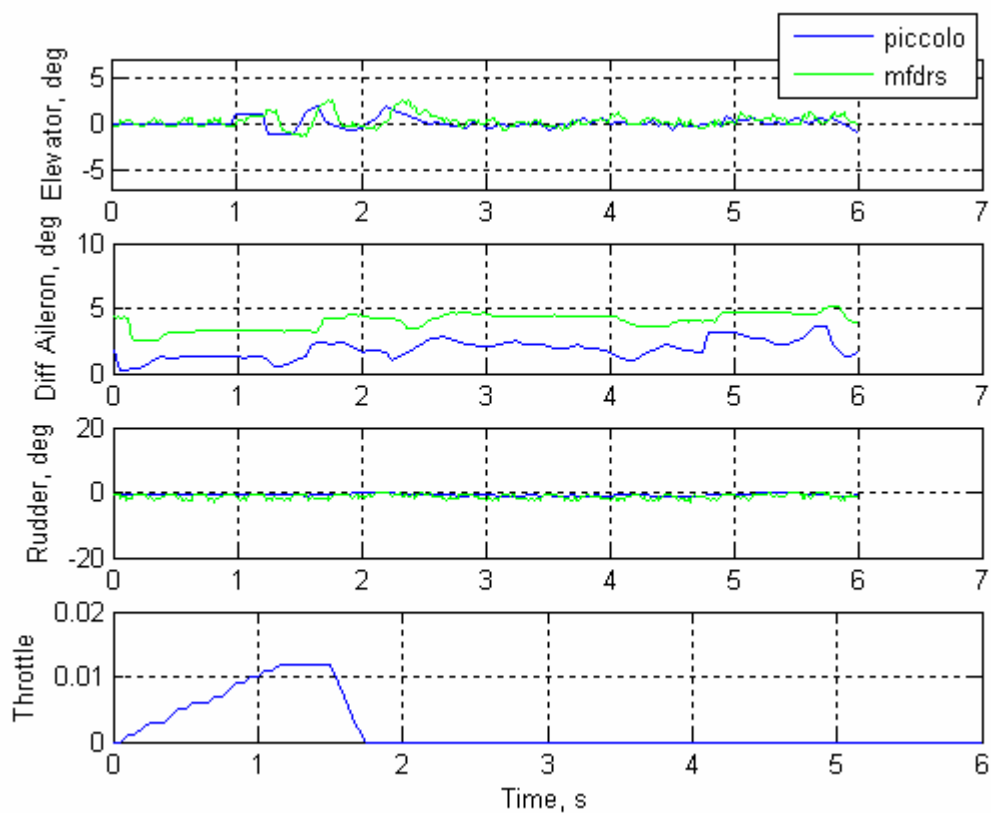
1.4.9 Elevator Doublet 2 (35kt)

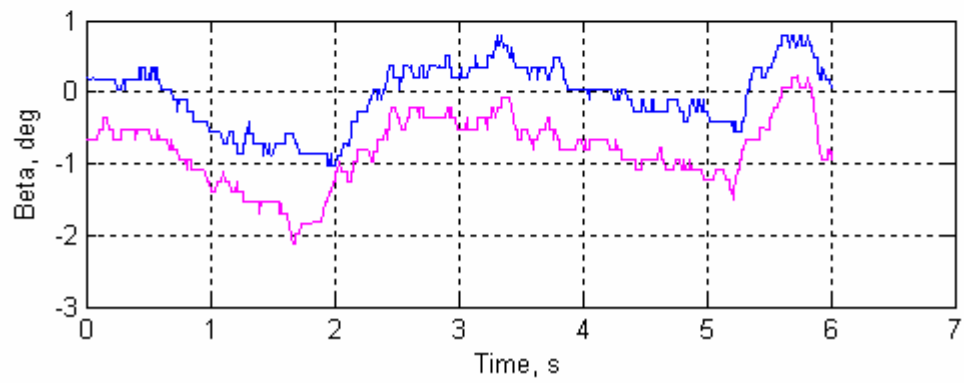
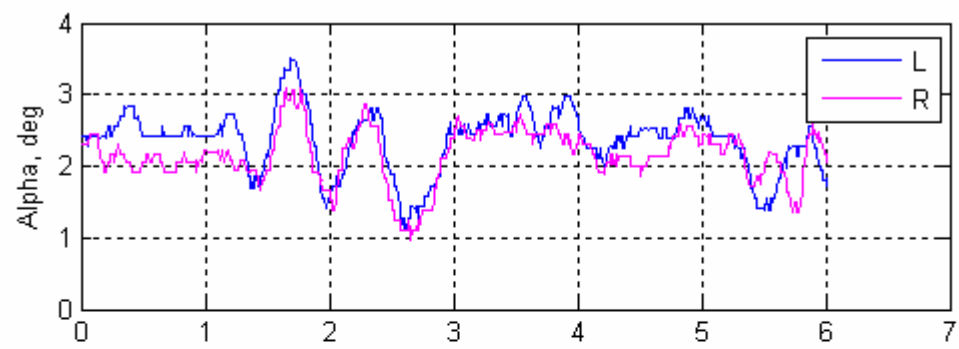
This doublet was done at the end of the 35kt glide to mark the end of the maneuver.





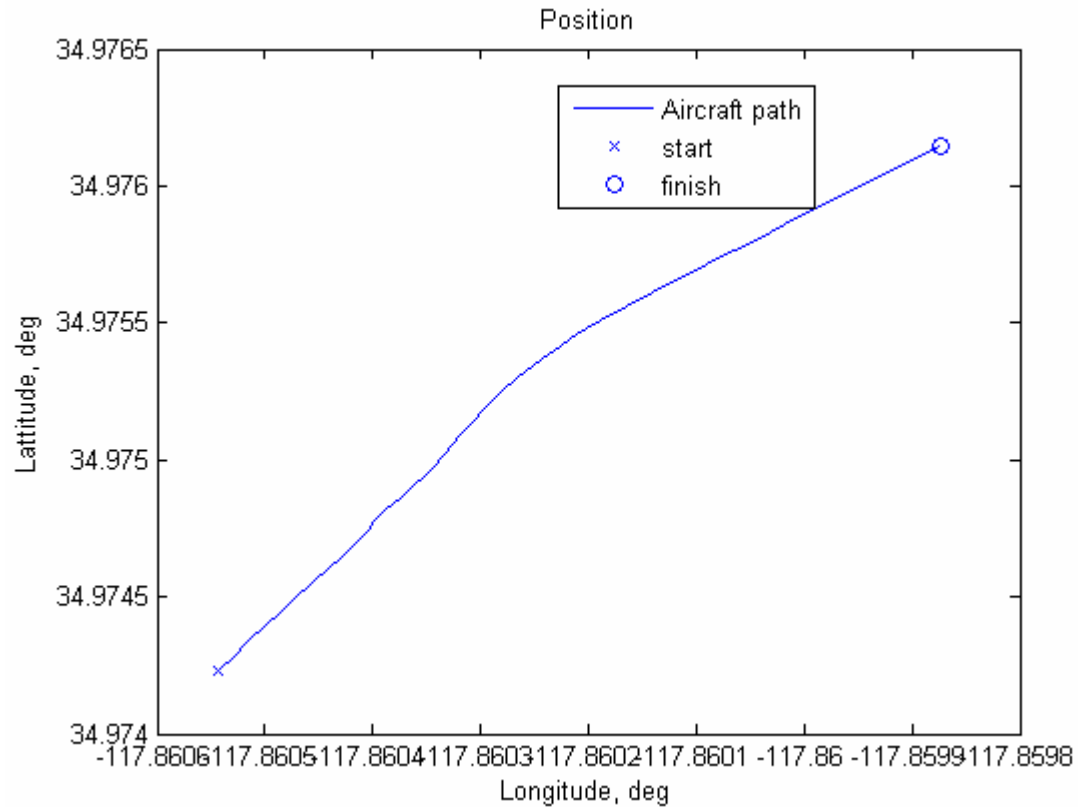


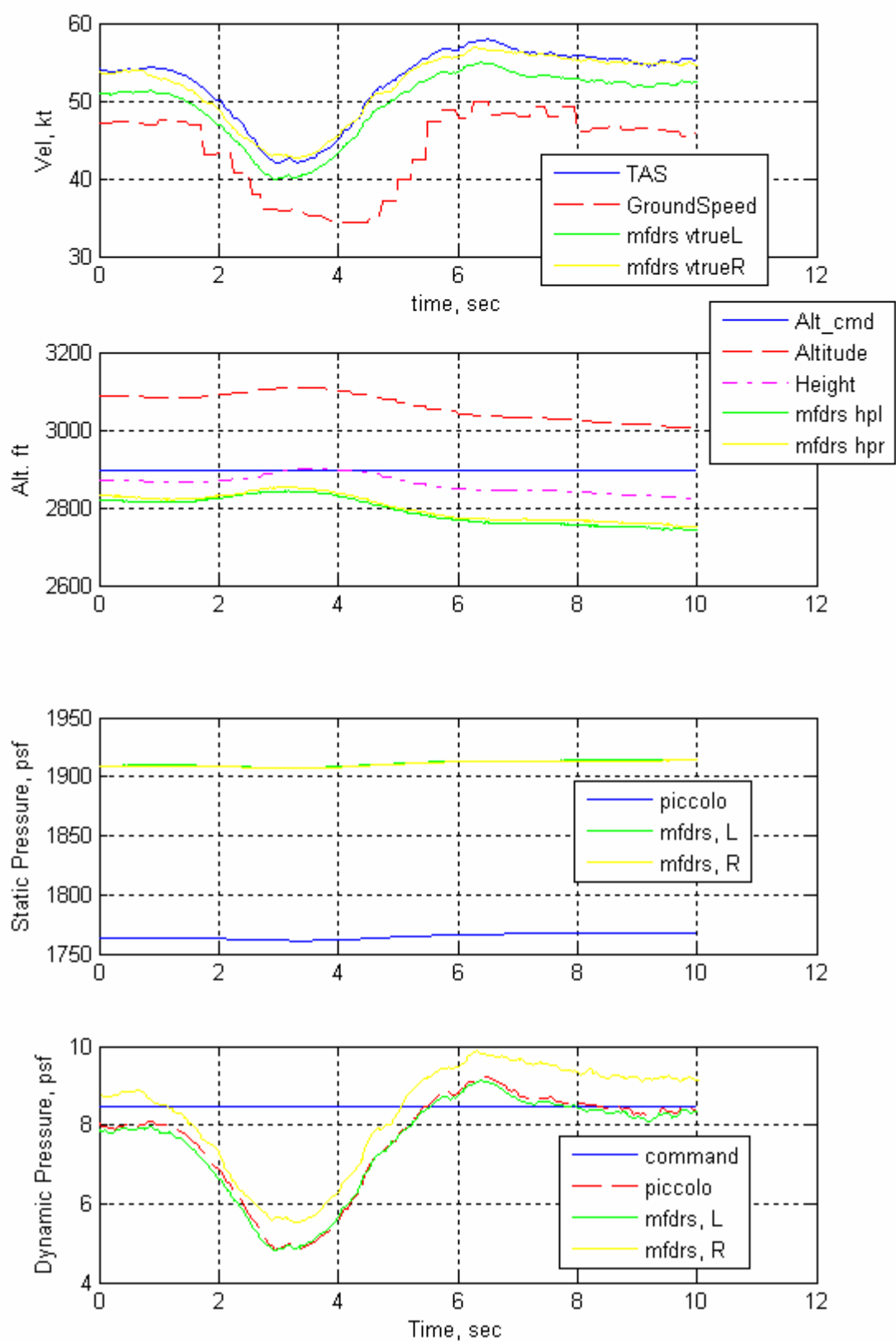


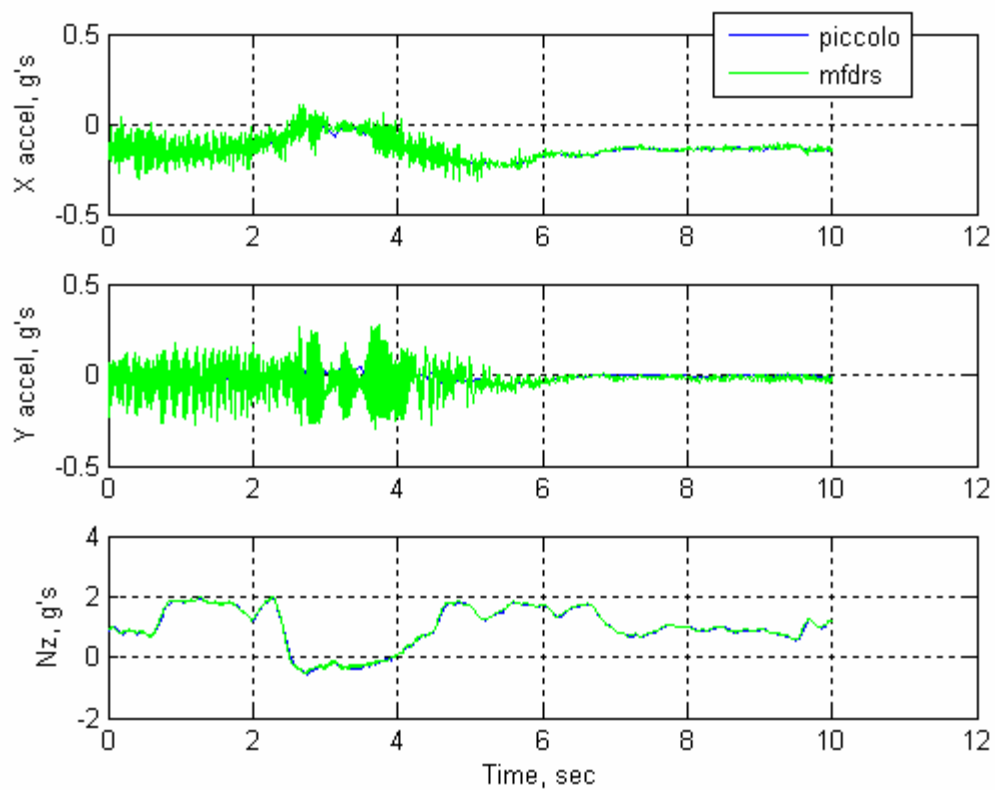
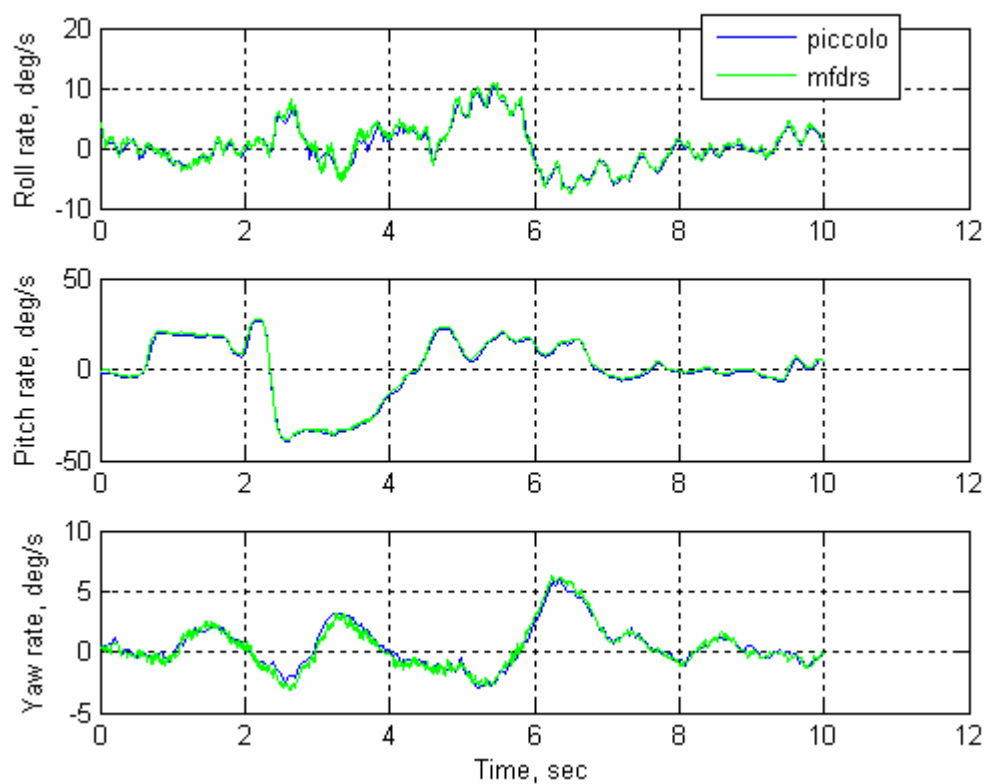


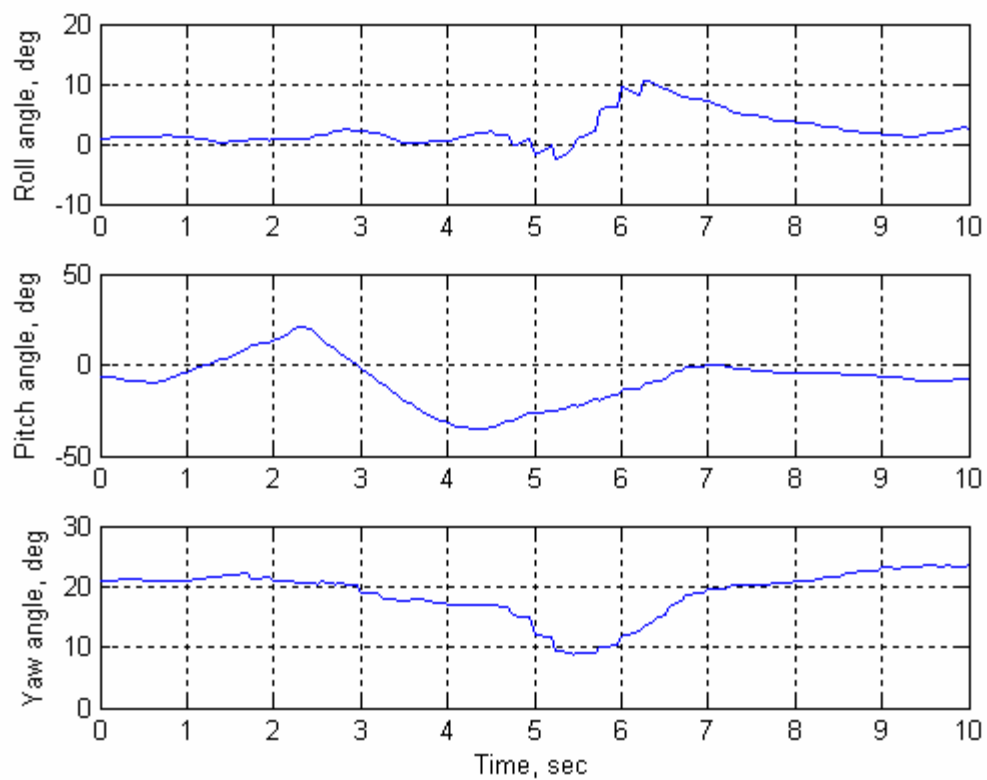
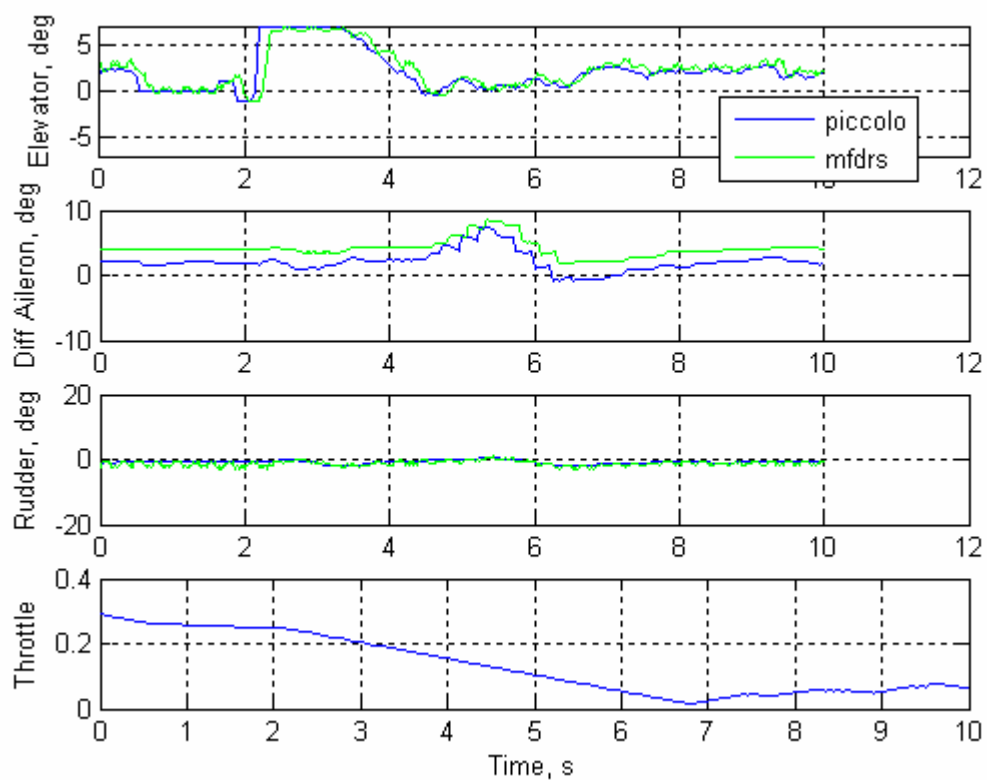
1.4.10 Elevator Doublet 3 (55kt)

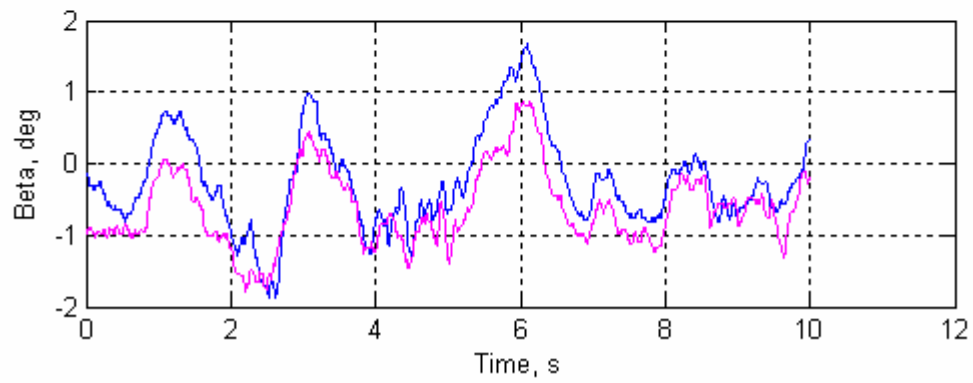
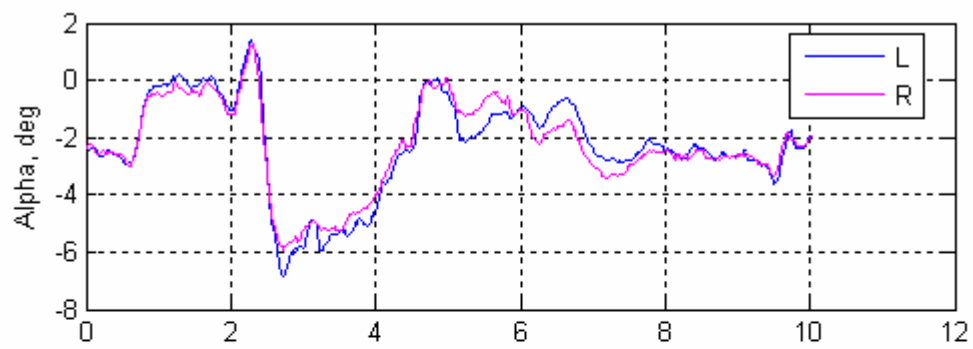
This extremely large doublet was done at the start of the 55kt glide. The doublet was incorrectly set to start at zero instead of the trim position. The airplane did not stay on condition. Throttle was not zero for this doublet.





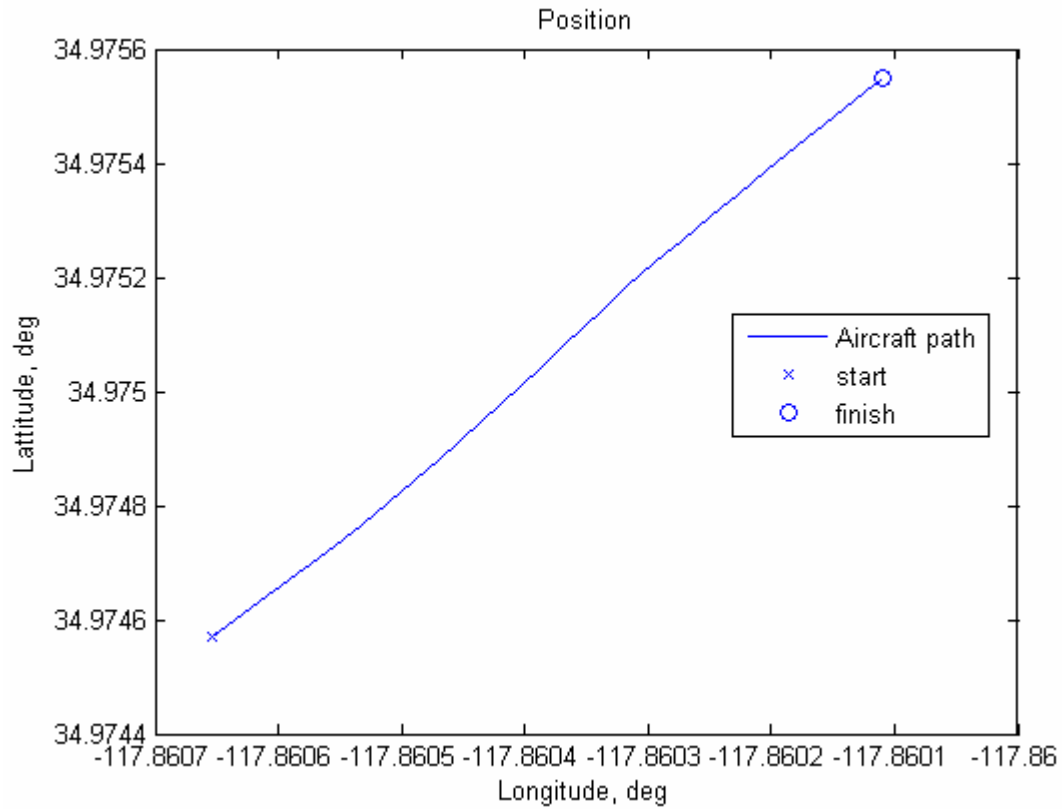


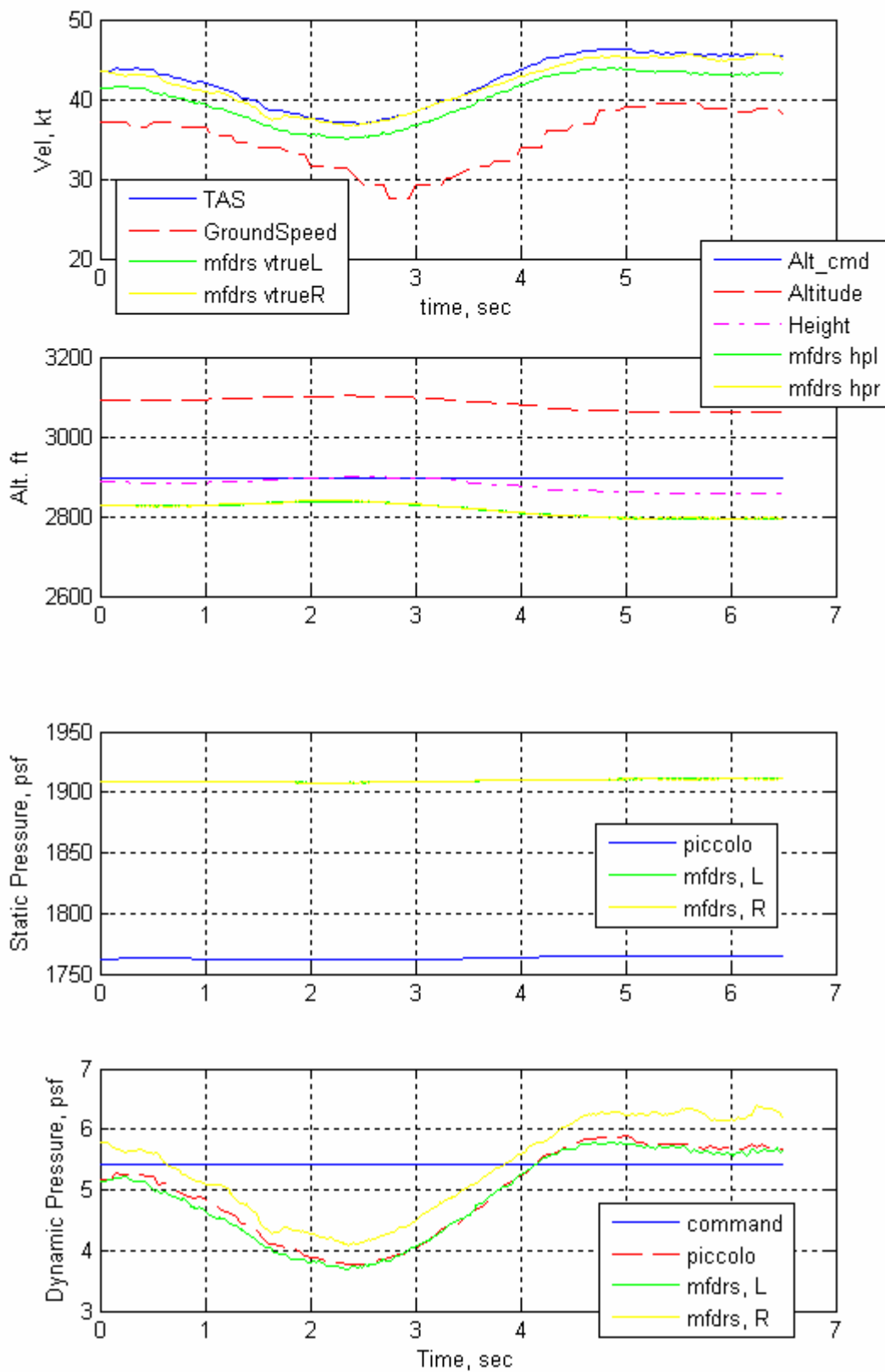


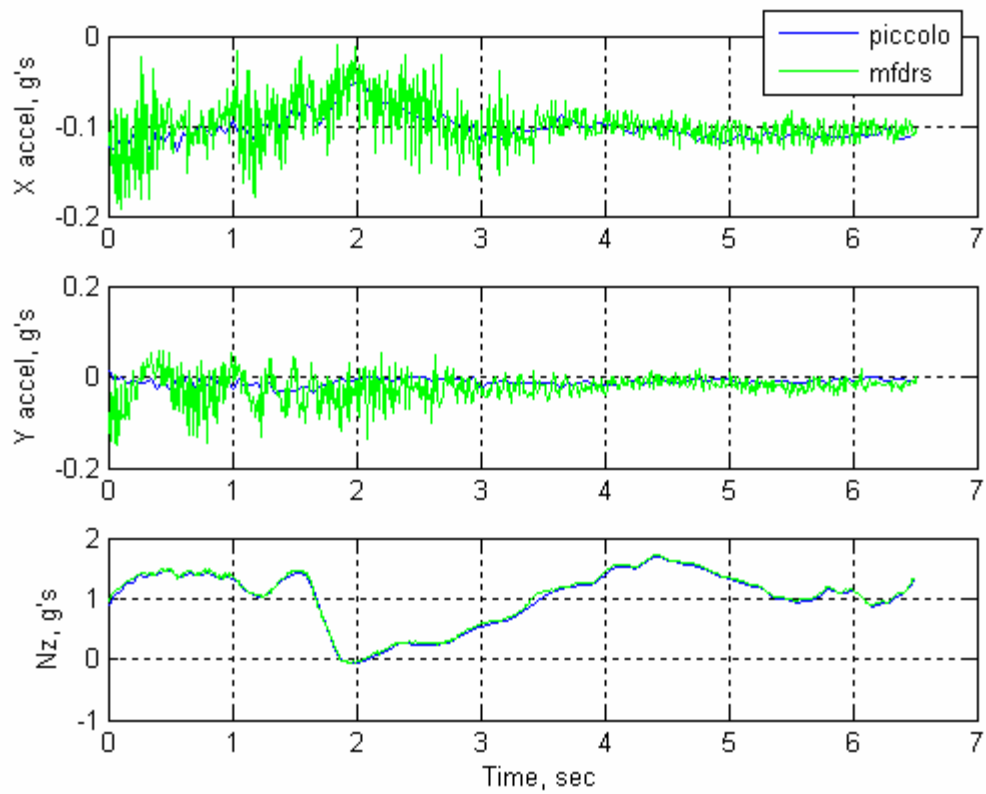
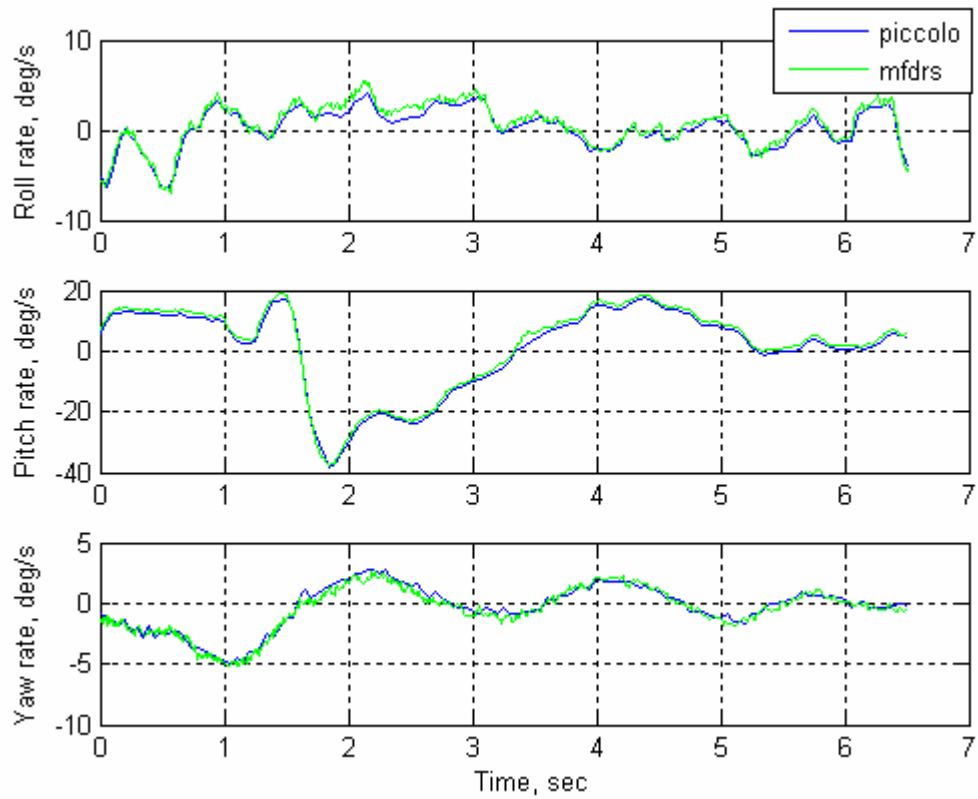


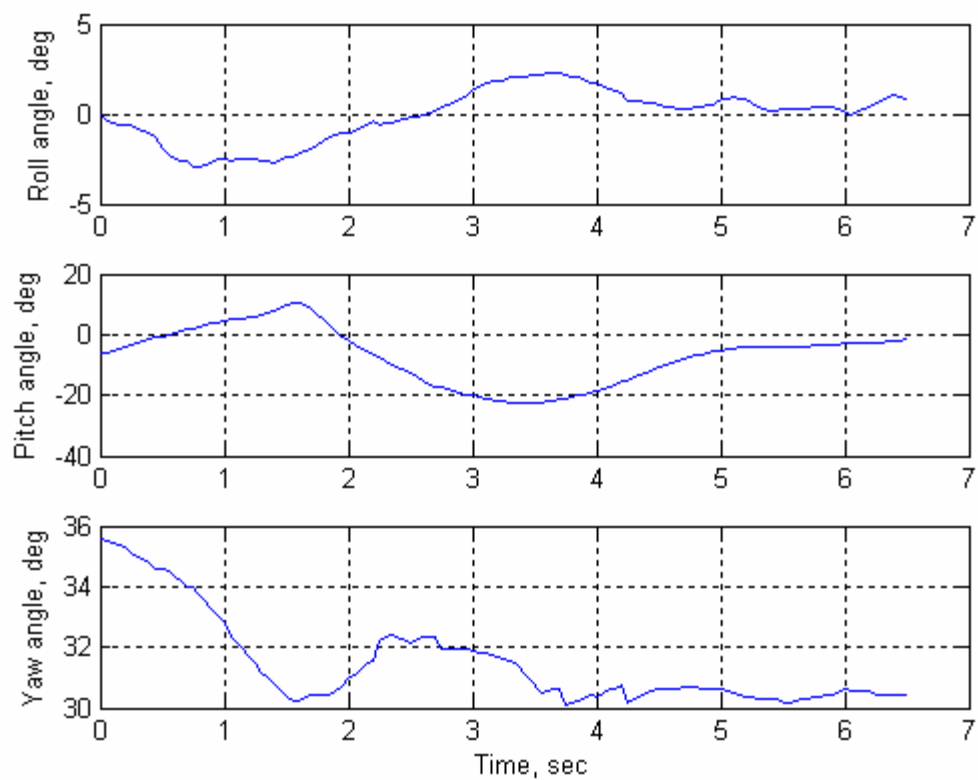
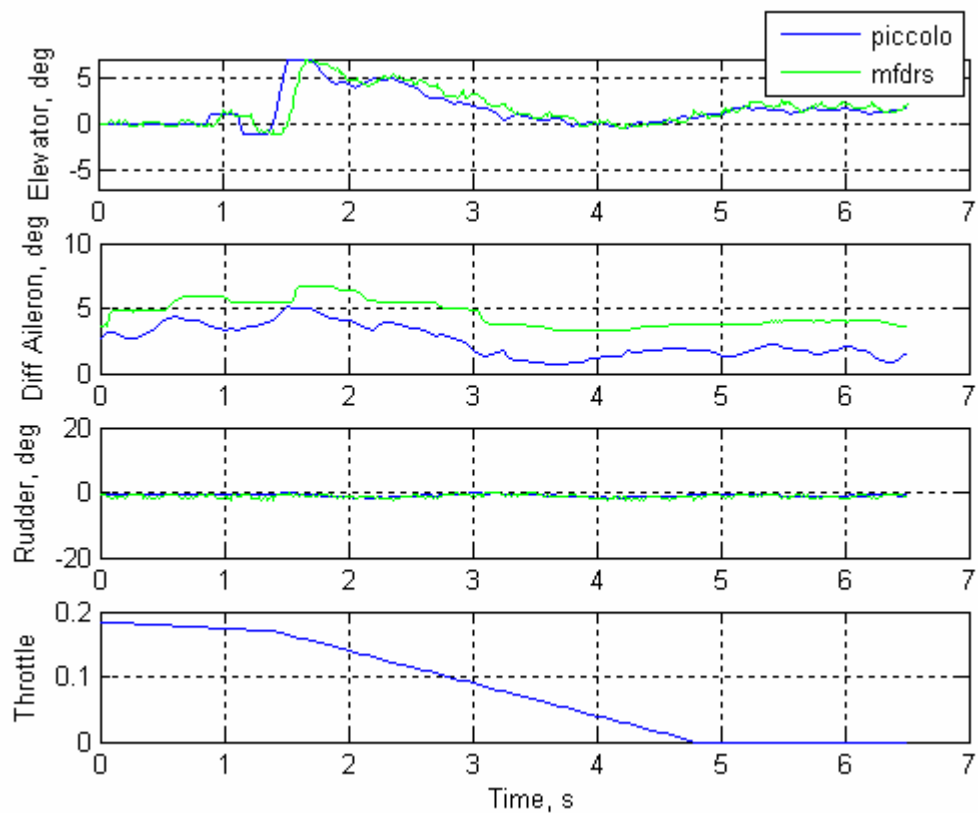
1.4.11 Elevator Doublet 4 (45kt)

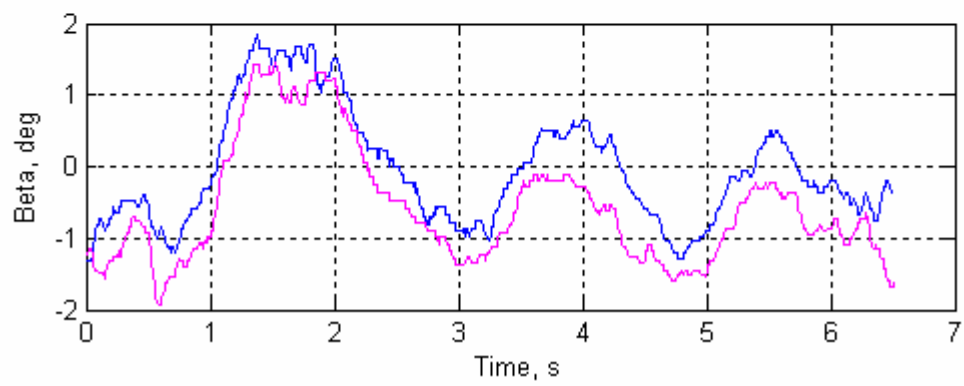
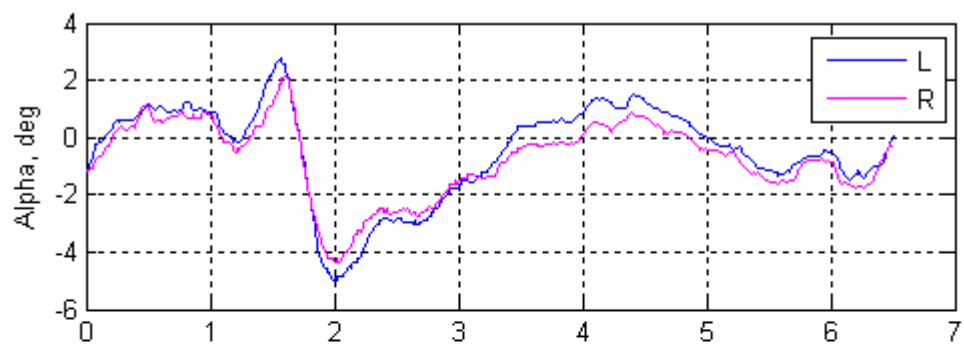
This data was taken from the 45kt glide. Huge elevator doublet was a result of an incorrect setting on the operator interface to start maneuver at zero instead of trim elevator. Throttle ramped to zero just after doublet.





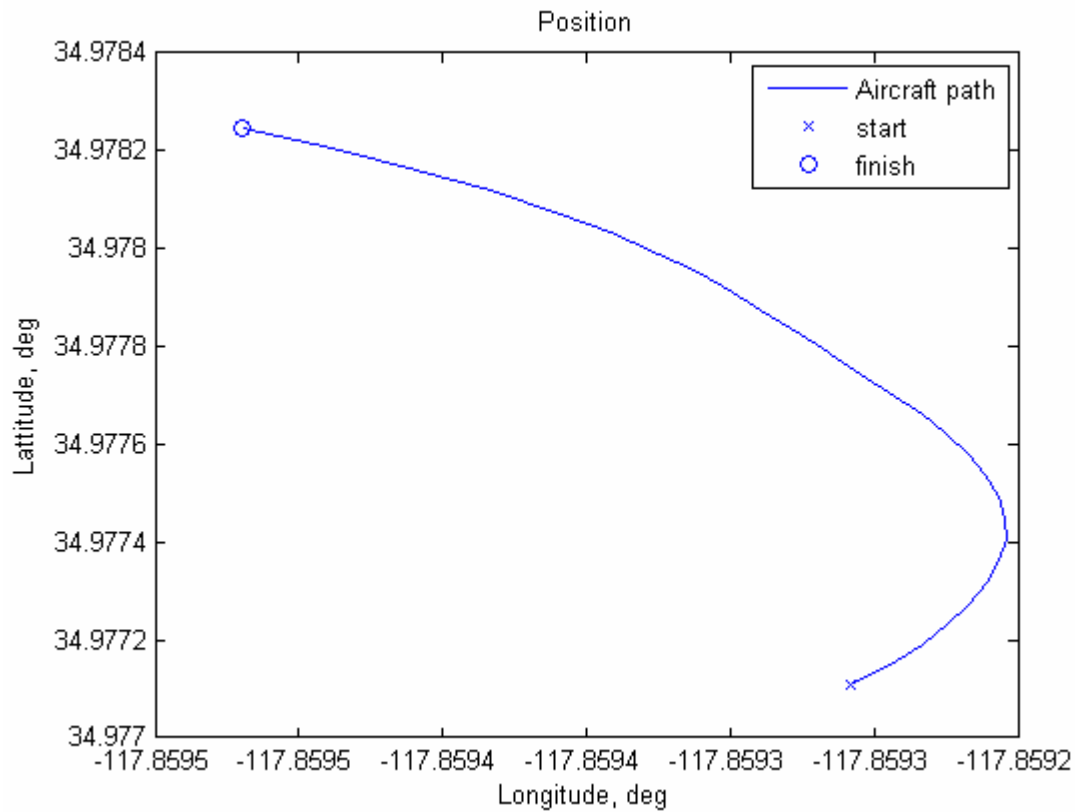


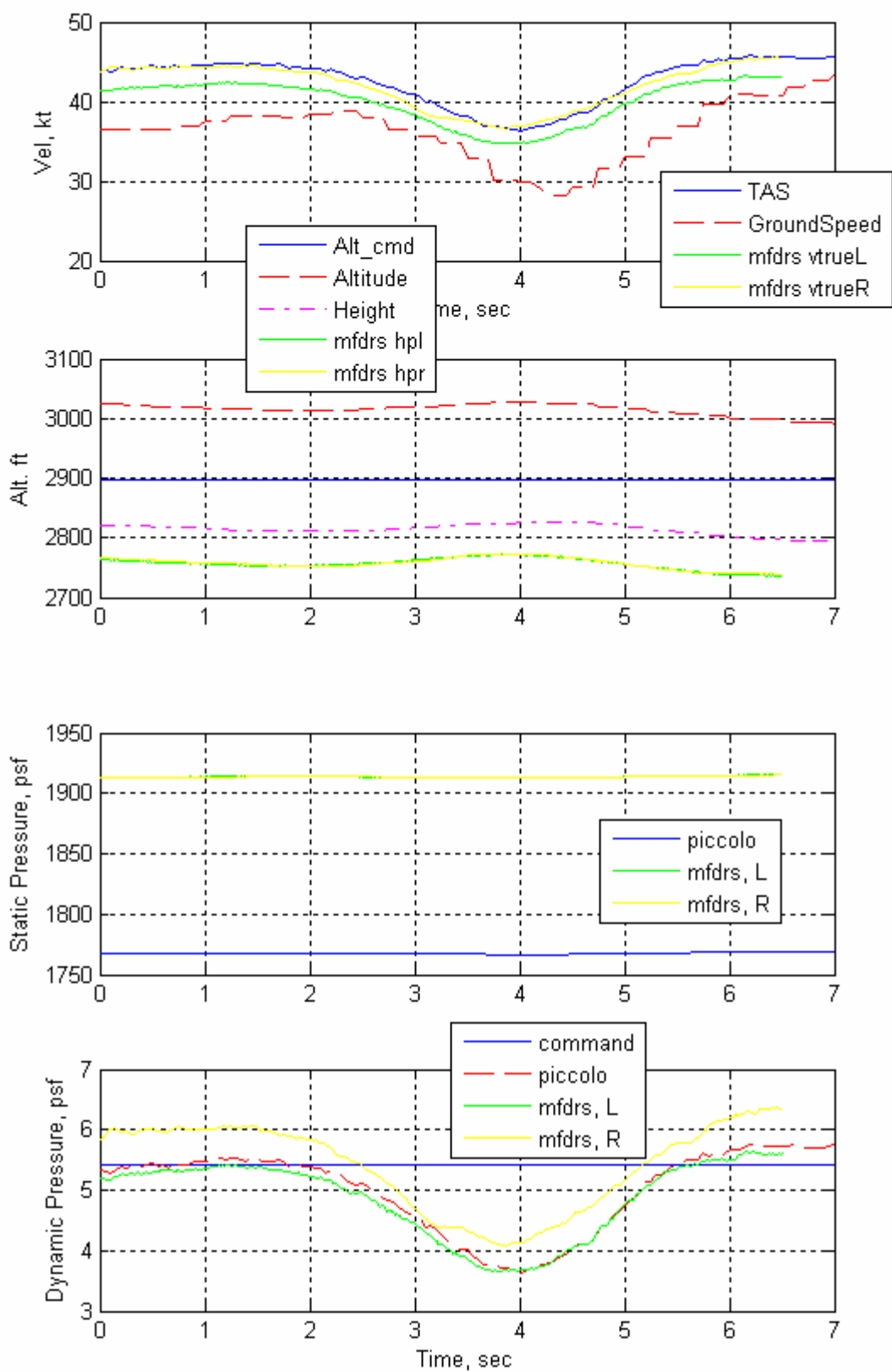


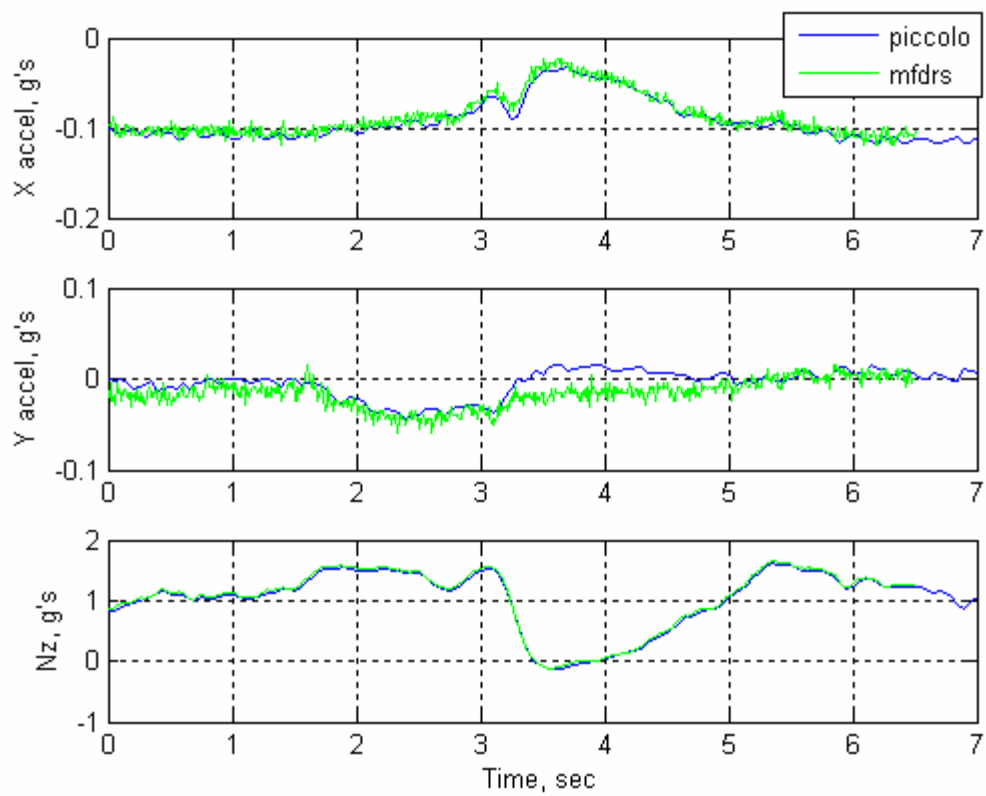
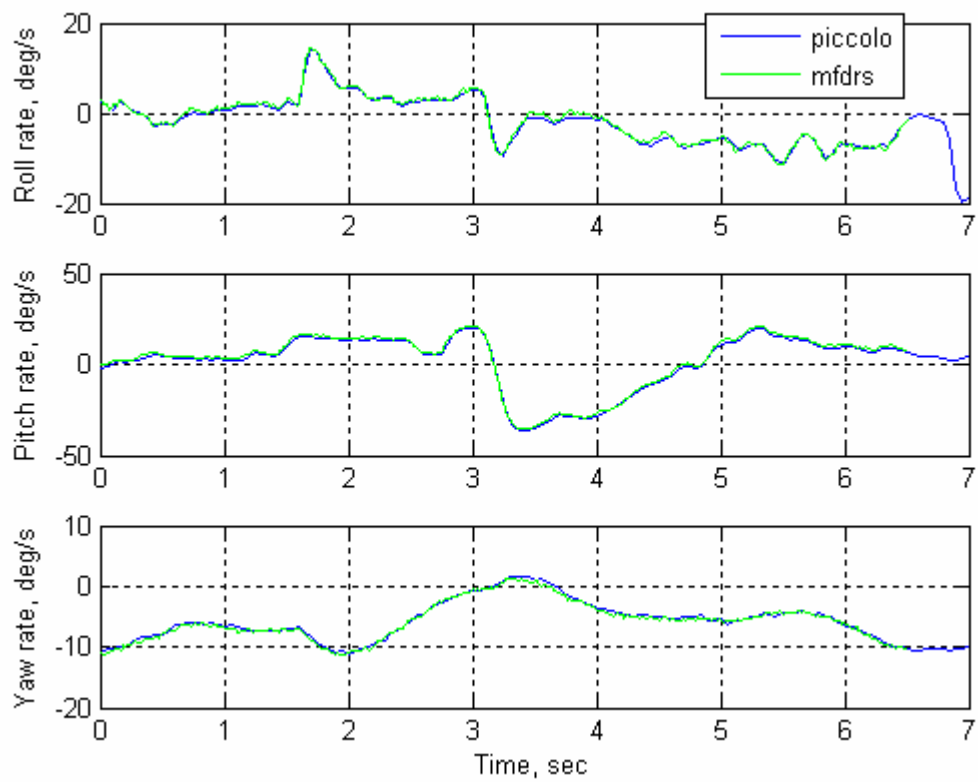


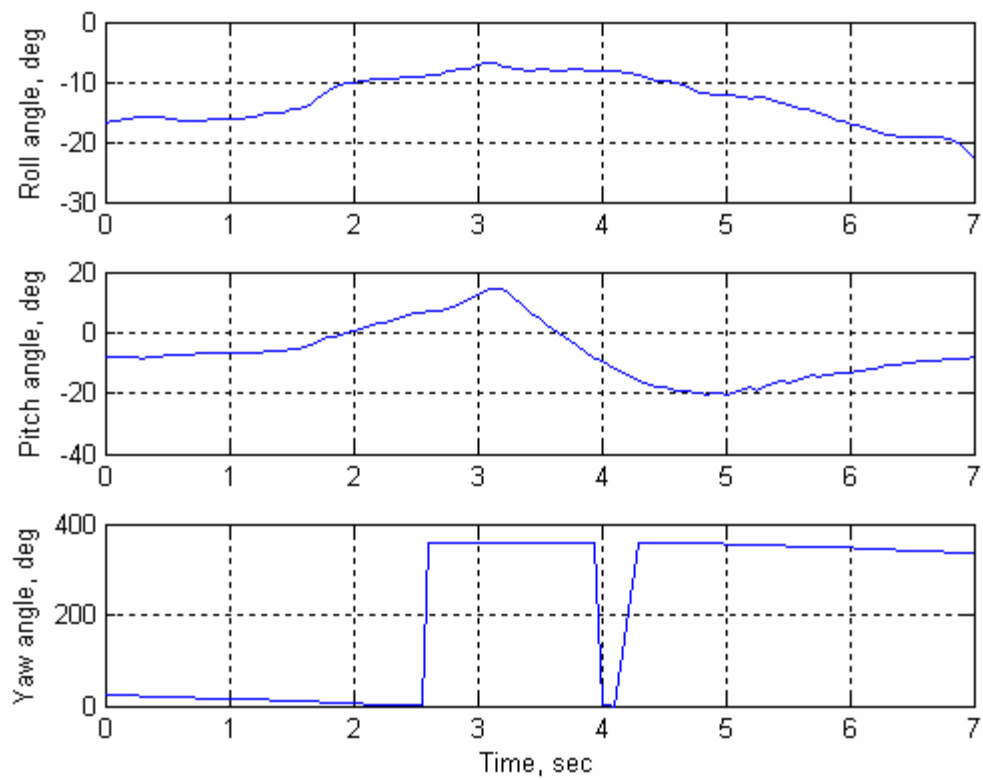
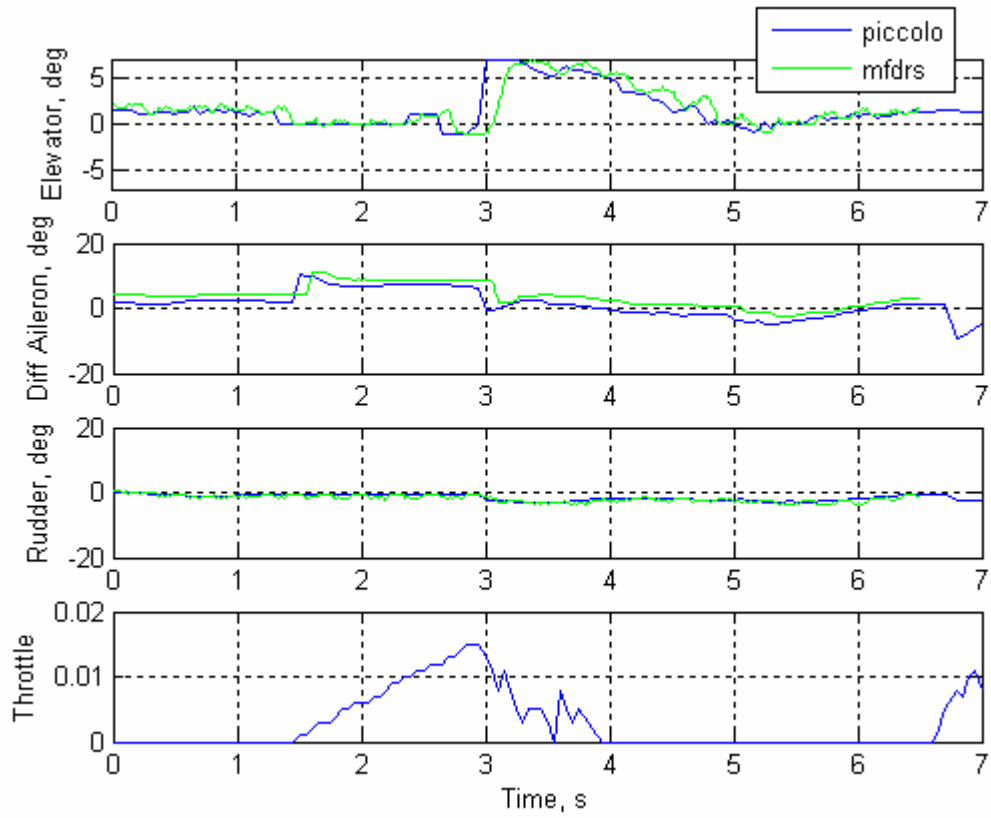
1.4.12 Elevator Doublet 5 and Turn 3 (45kt)

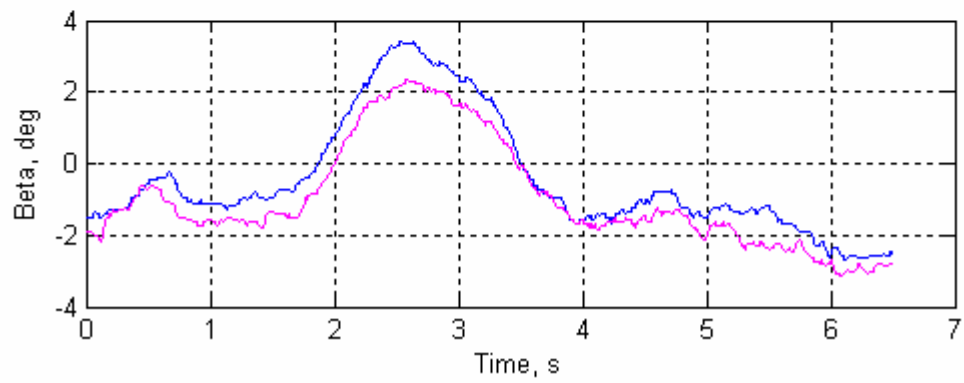
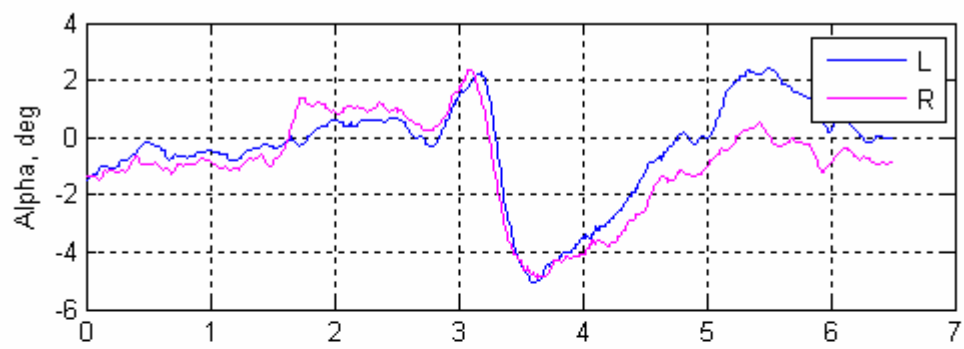
This data was taken from the 45kt glide. Huge elevator doublet was a result of an incorrect setting on the operator interface to start maneuver at zero instead of trim elevator. The aileron command also moved to about 10deg during the doublet. This seems to be the result of crossing a waypoint during the maneuver. The exact timing of the aileron and elevator commands, making them correlated and poor for PID, seems to be a bit of bad luck. Note that the piccolo and MFDRS Y-accelerations do not match as well as they usually do. The reason for this is unknown.





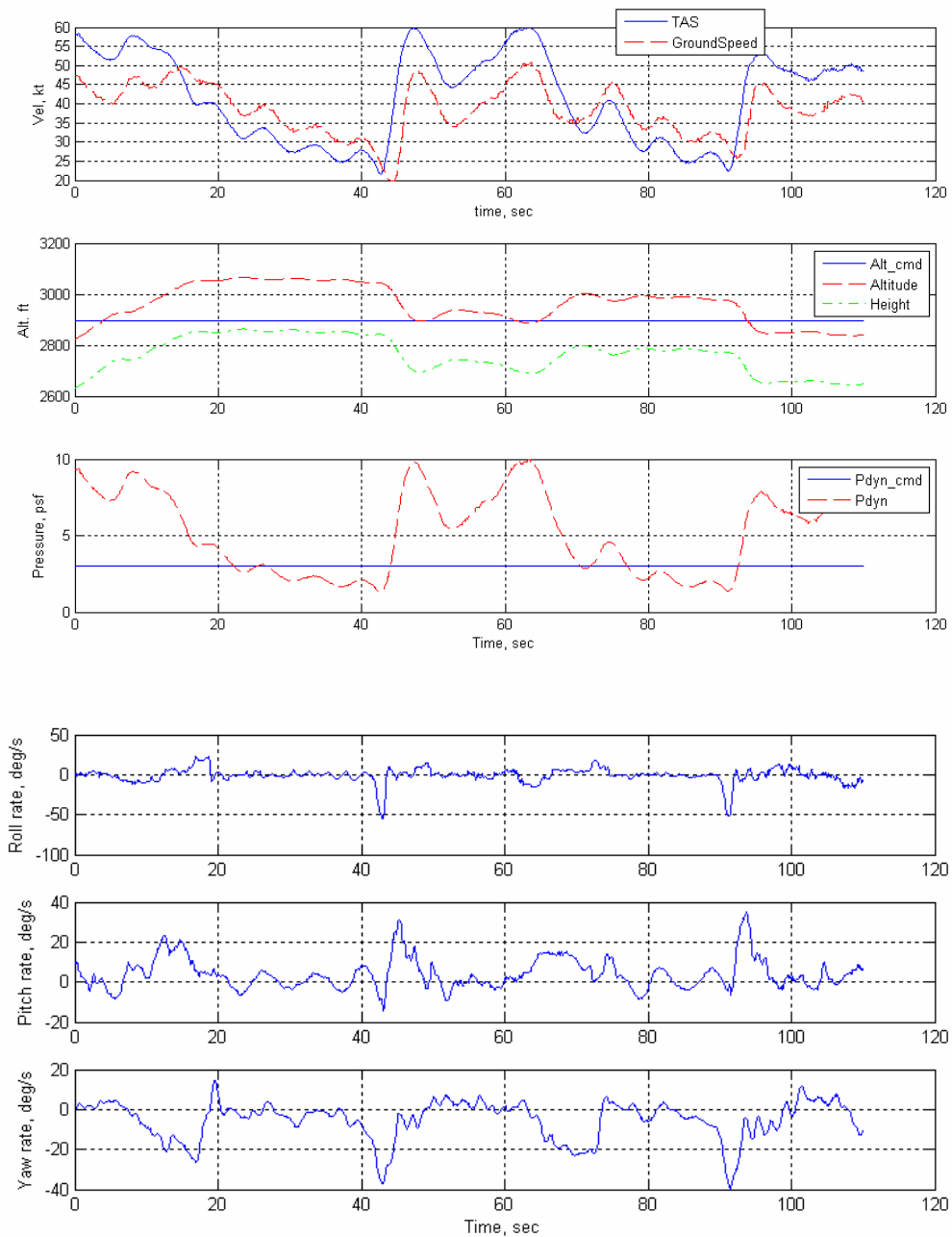


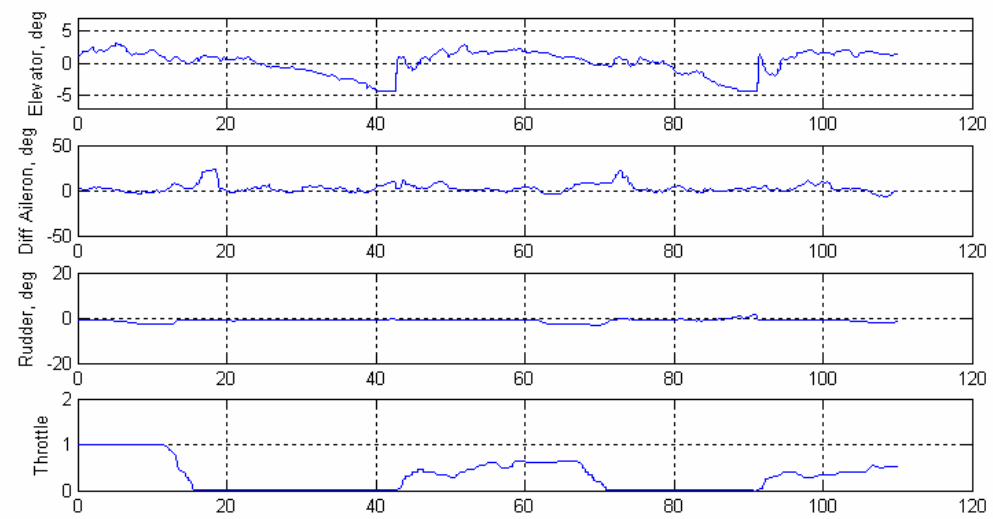
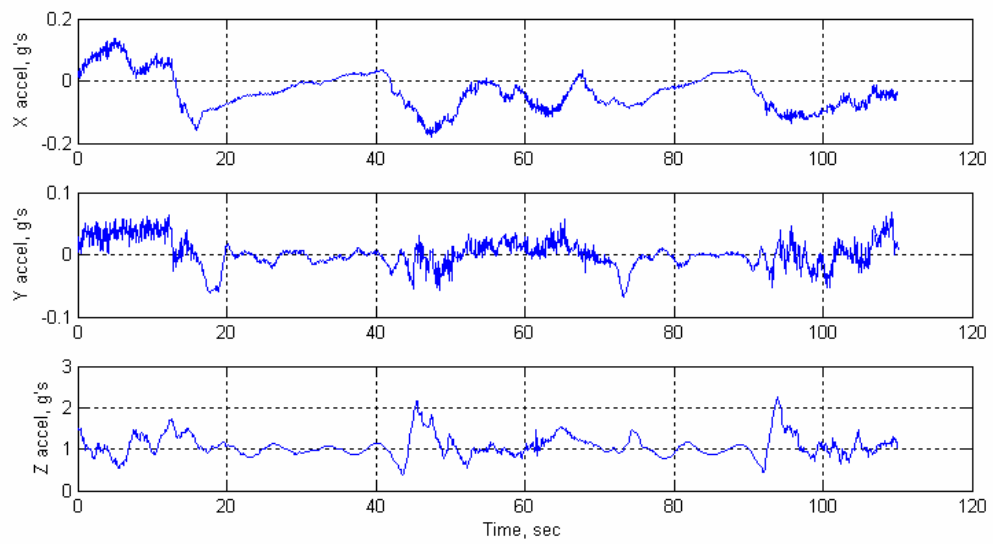


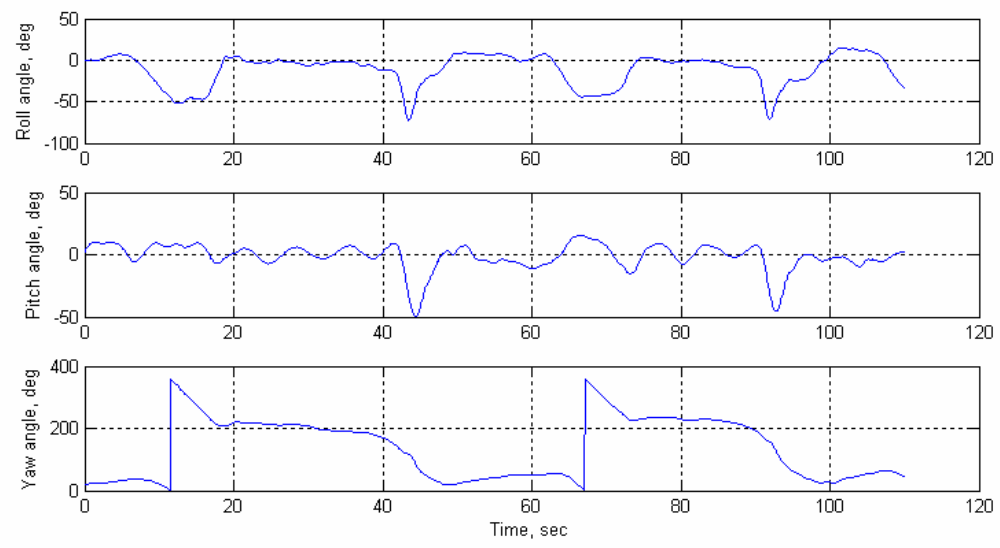


1.4.13 Stalls

Stalls were performed under manual control with the motor off. Stall speed seems to be about 23kt. Stalls were predictable, always dropped the left wing (60deg) and took about 150ft to recover. Pilot seems to recover 2nd stall easier than the first. No adverse handling qualities were reported by the pilot for these or any previous stalls.

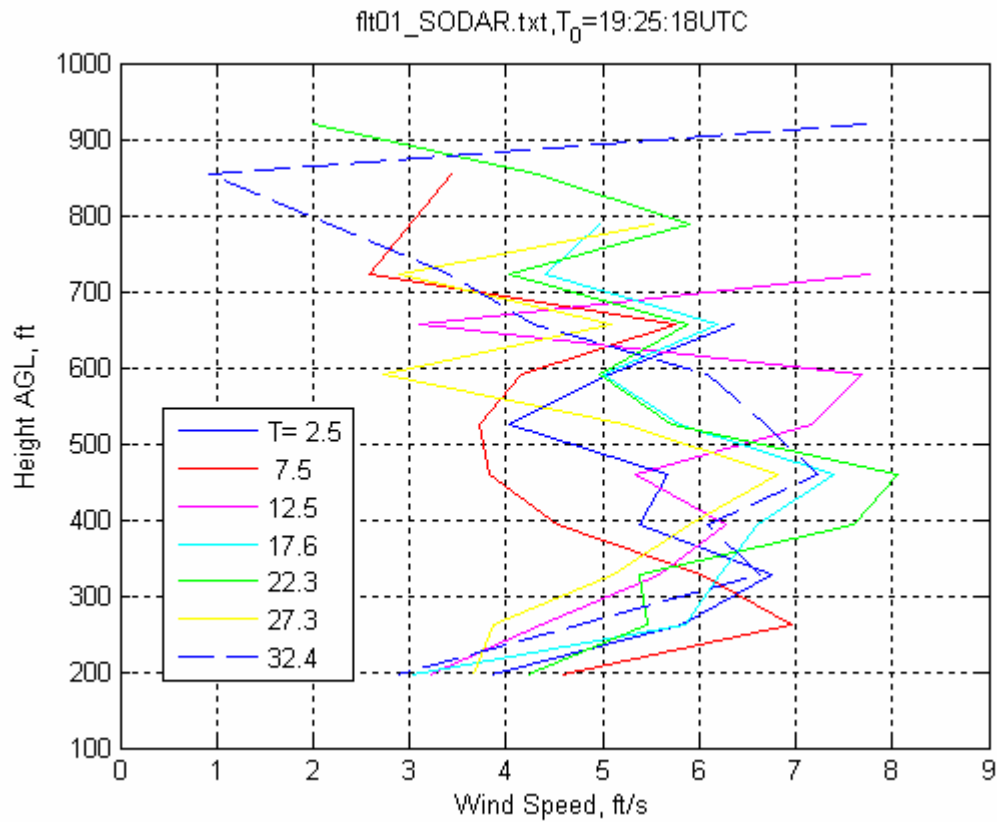


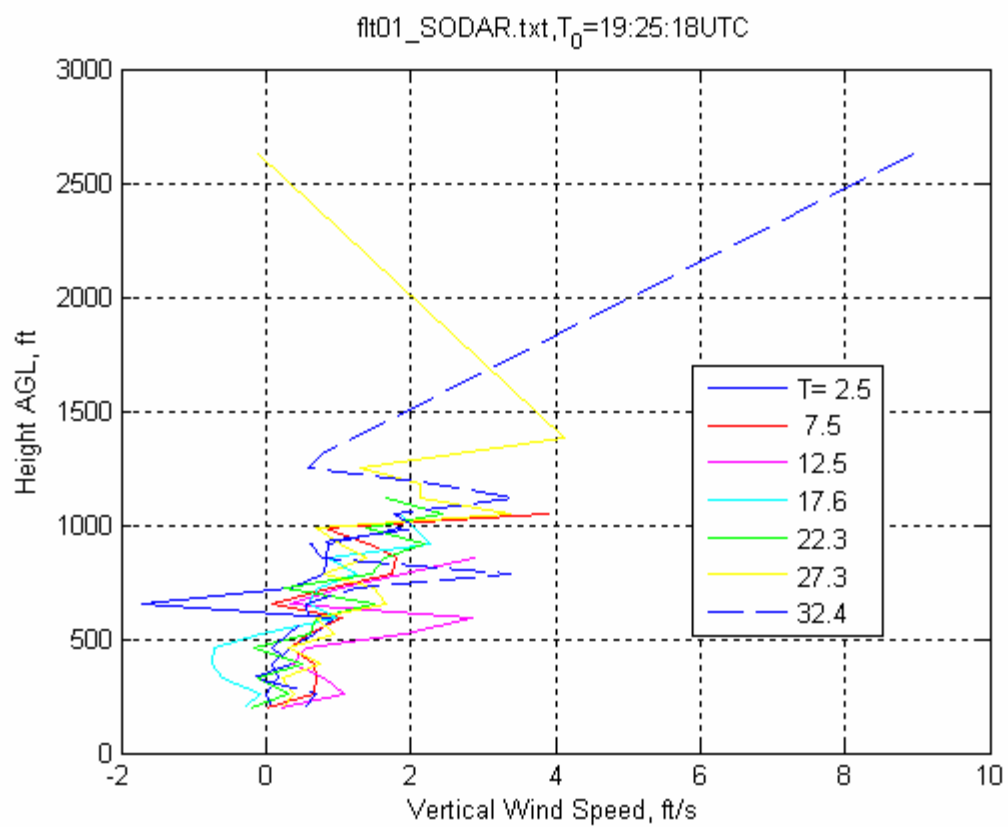
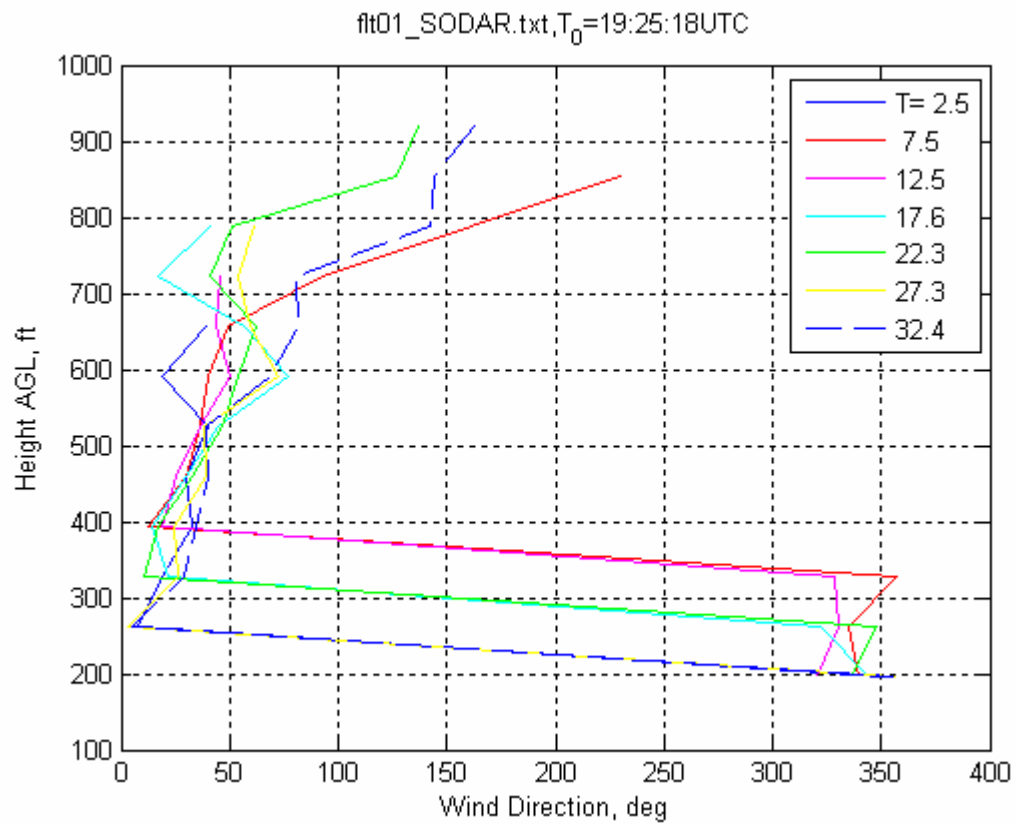


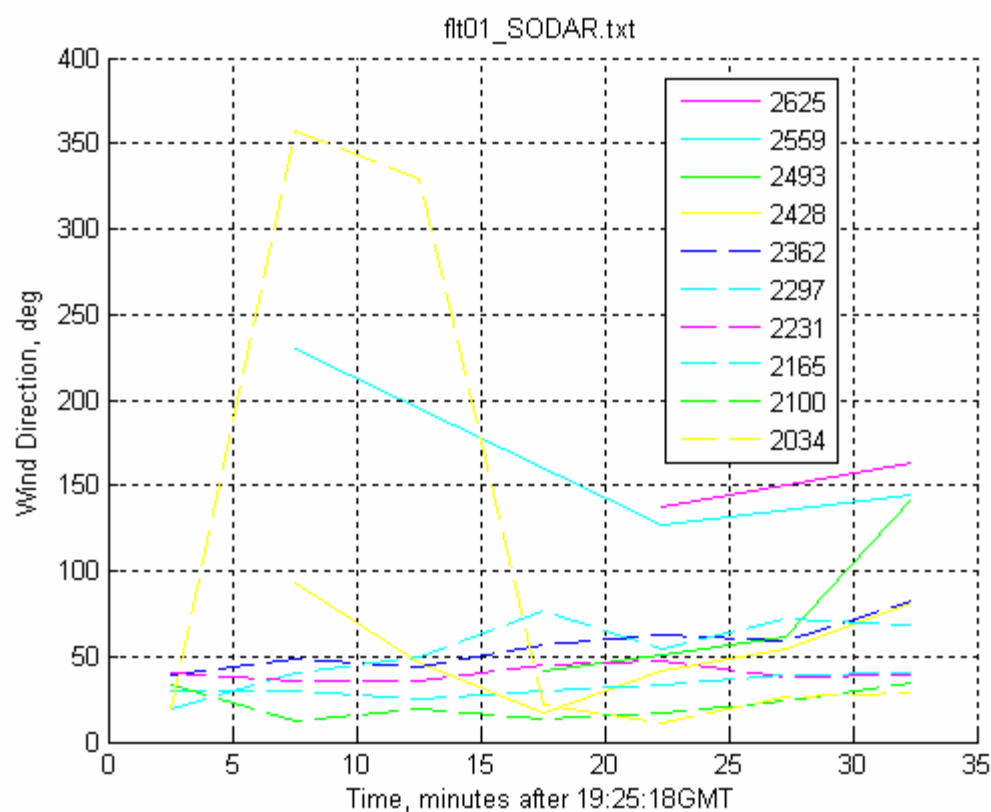
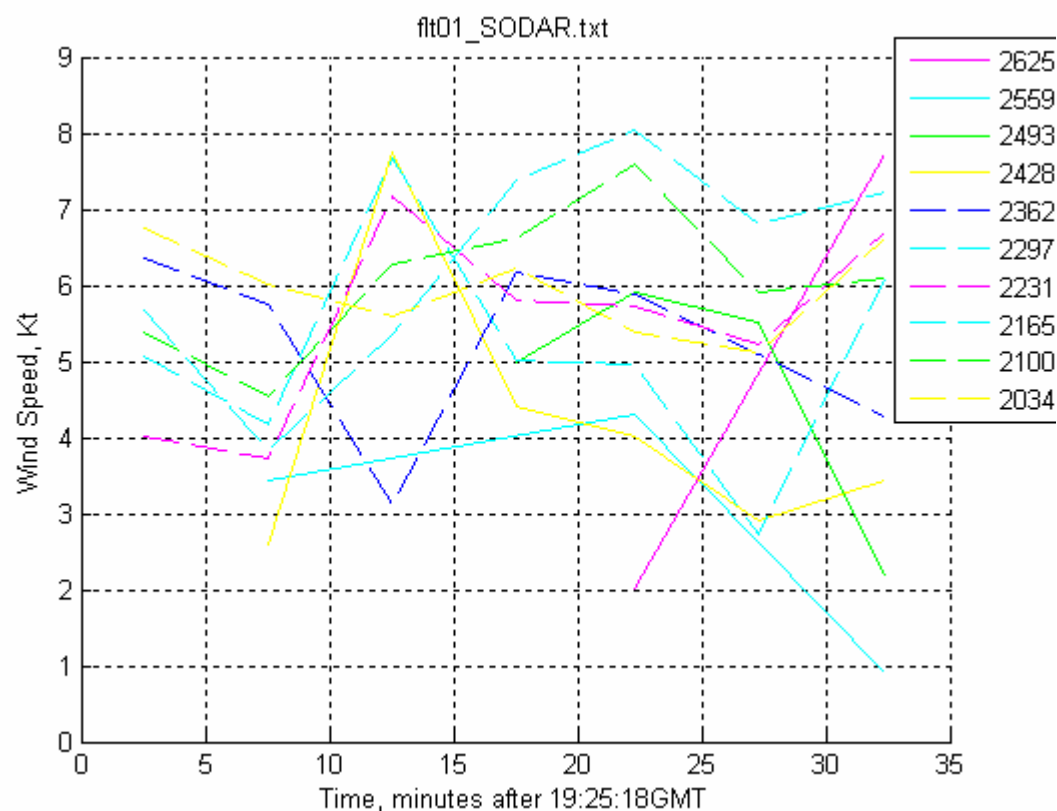


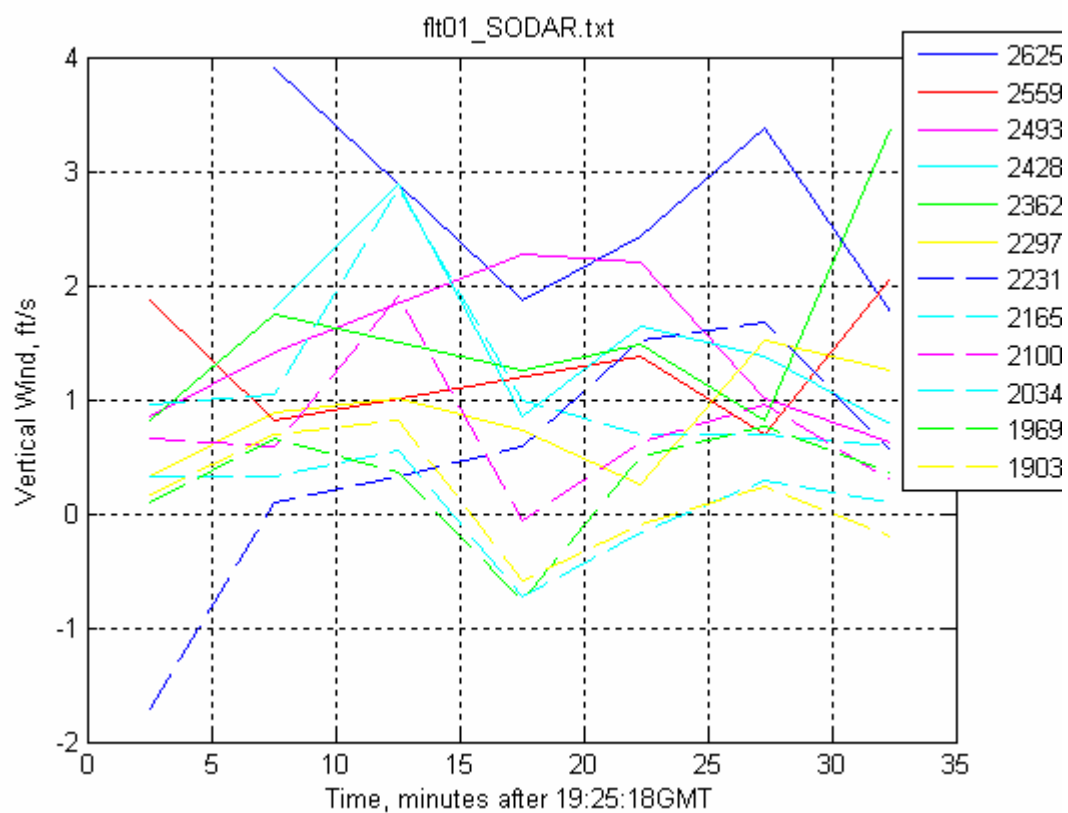
1.4.14 SODAR Data

SODAR Data for flight 1 was gathered with the NASA SODAR located on the Northwest edge of the lakebed near the shuttle area. The test location is approximately 2 miles from the SODAR location. Start time for the SODAR data is 12/07/2006 19:25:18.



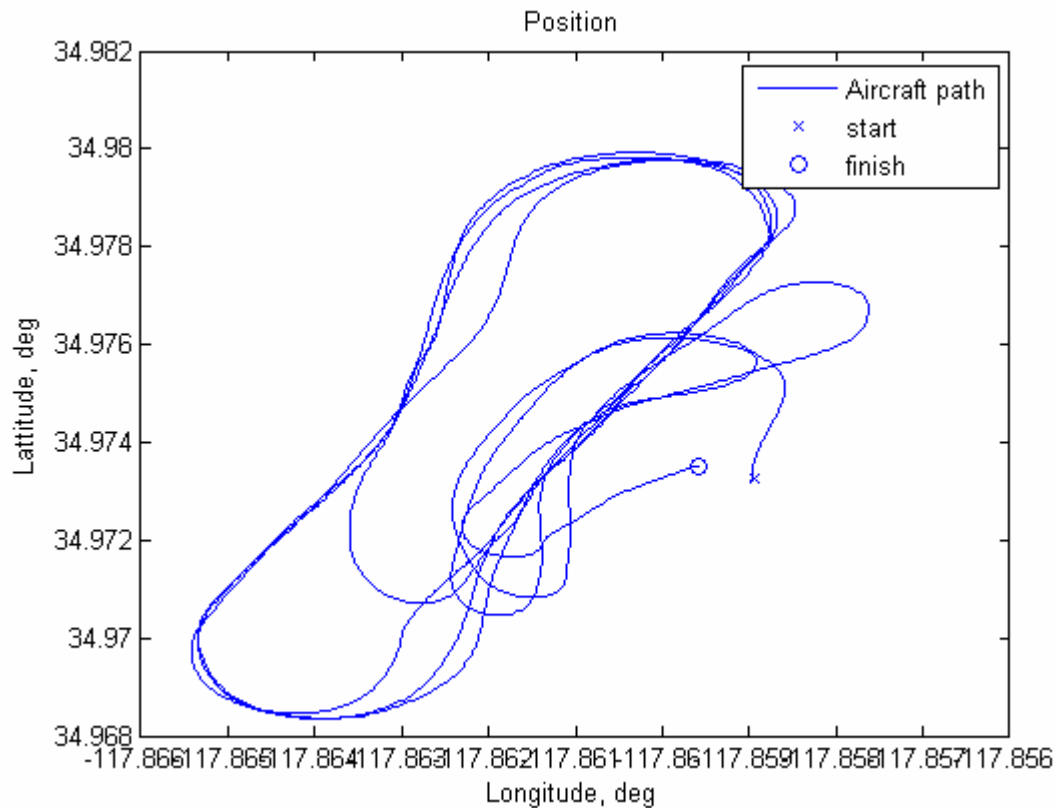


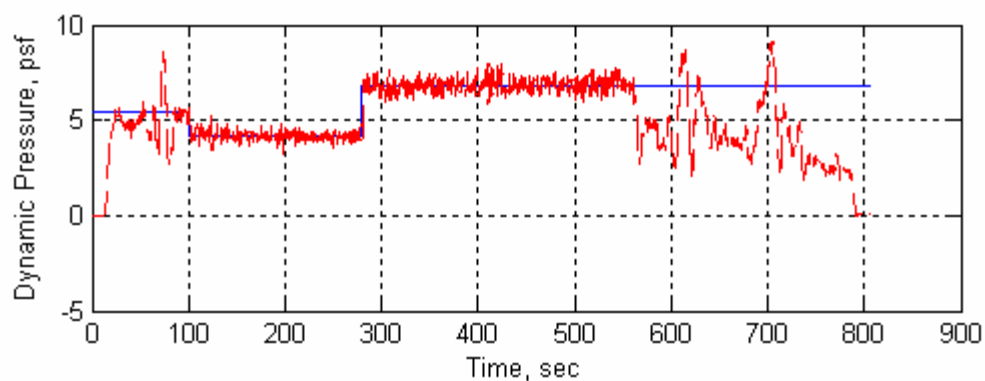
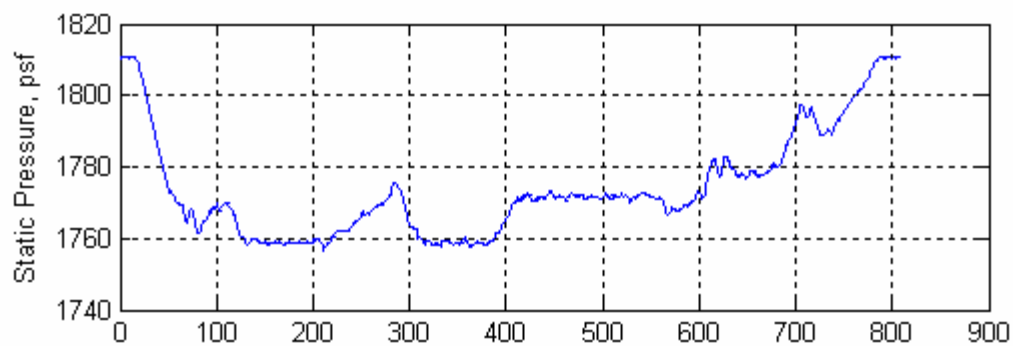
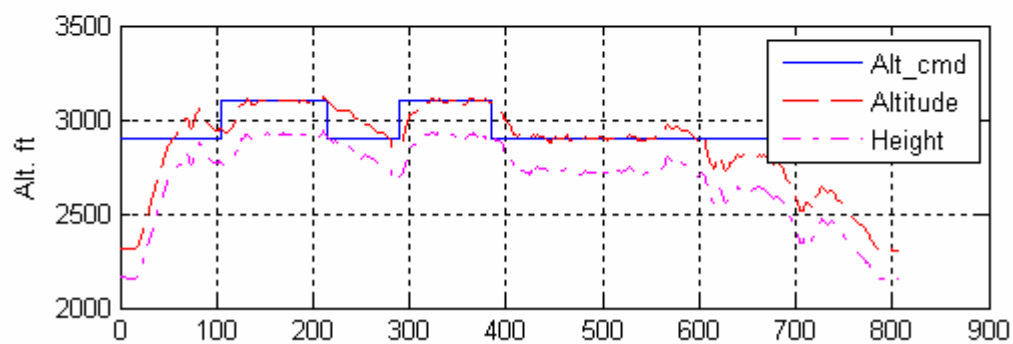
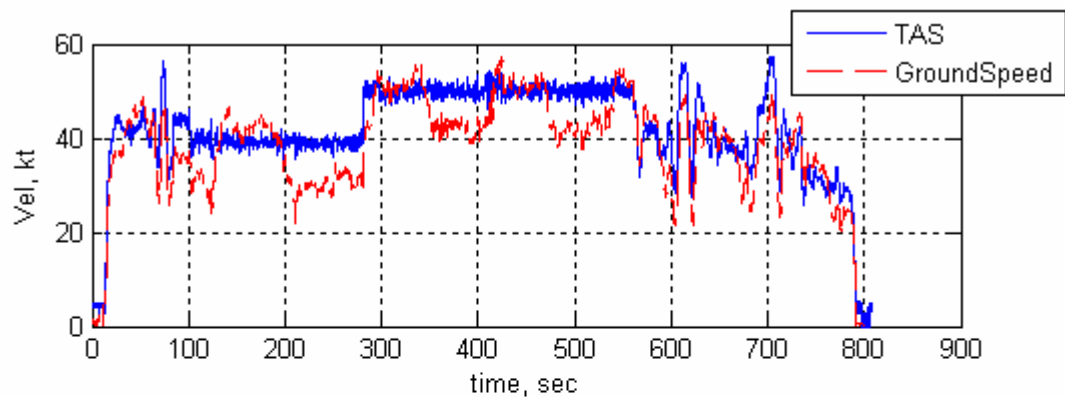


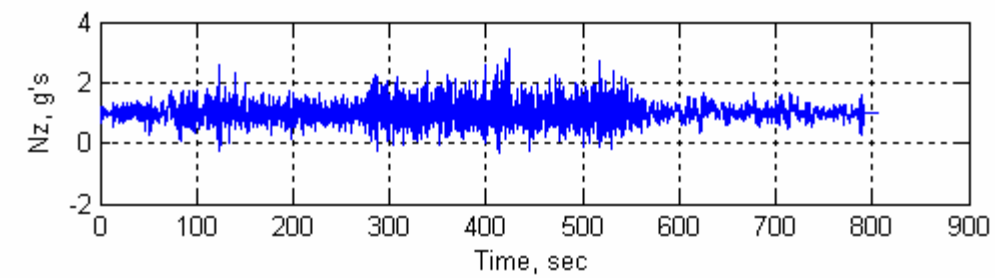
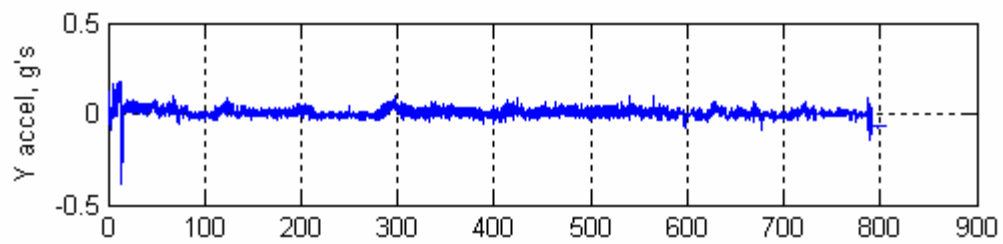
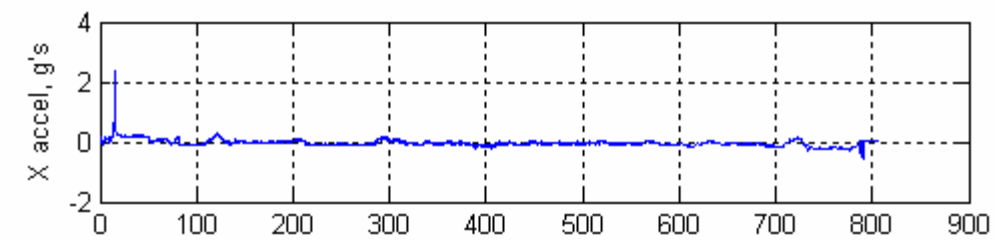
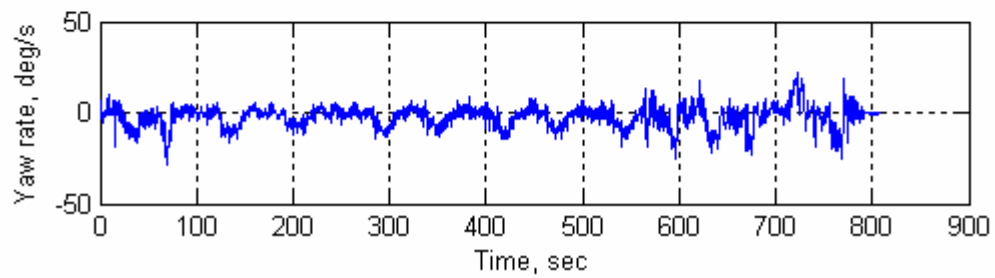
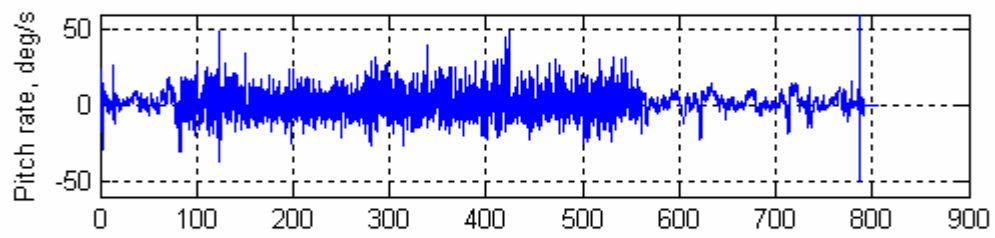
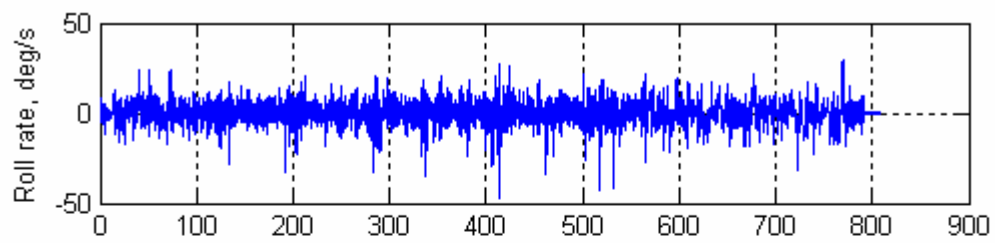


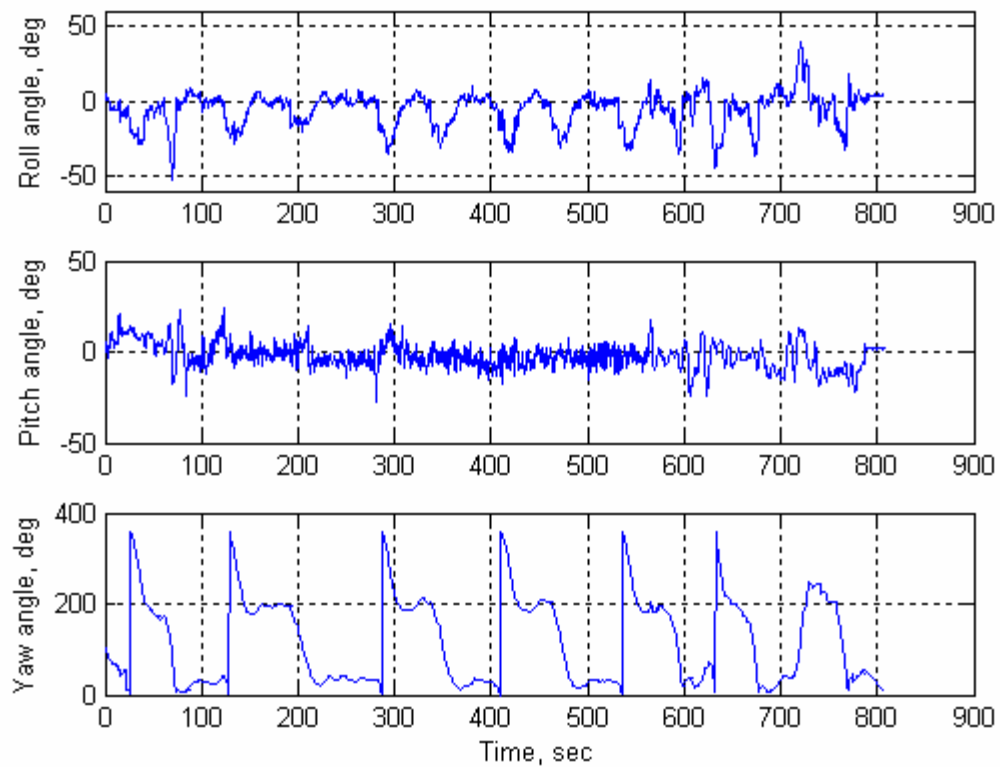
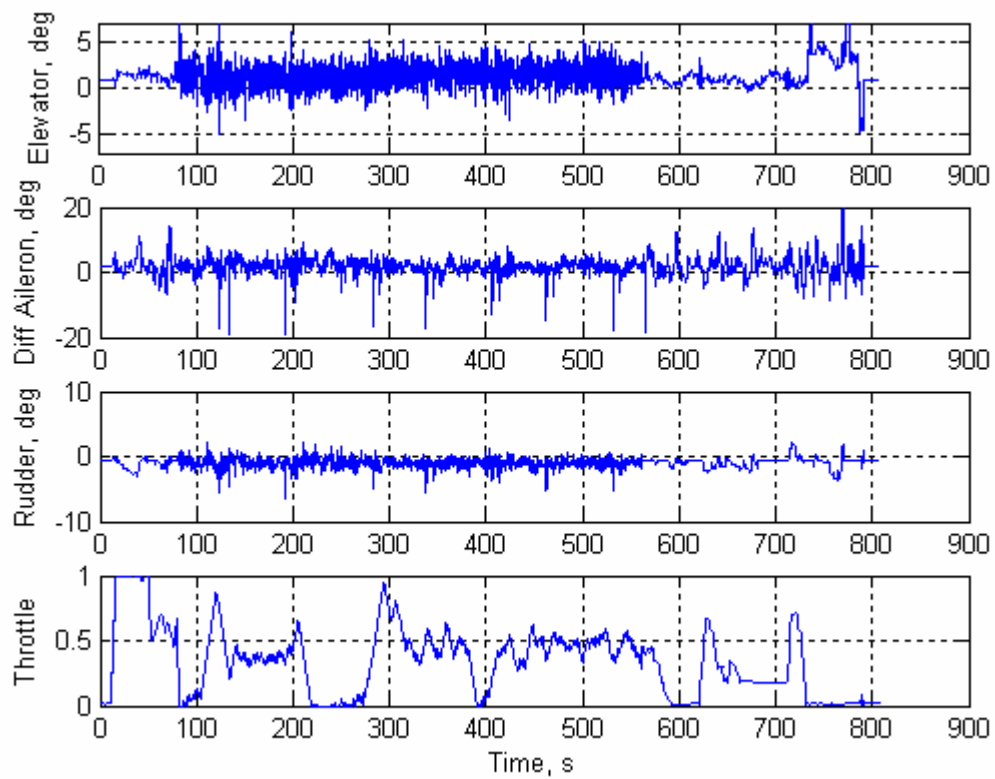
1.5 Cloud Swift 2, Flight 2

Flight 2 occurred on December 14, 2006 from 20:45 – 20:59 UTC (12:45 – 12:59 local). Flight 2 was used to perform additional speed polar maneuvers. No doublets were found in the flight 2 data. Several MFDRS files were taken during flight 2 to record the aircraft performance during the speed polar maneuvers. Piloted Pitch UP, Push Over (POPU) maneuvers were flown and recorded with the MFDRS.

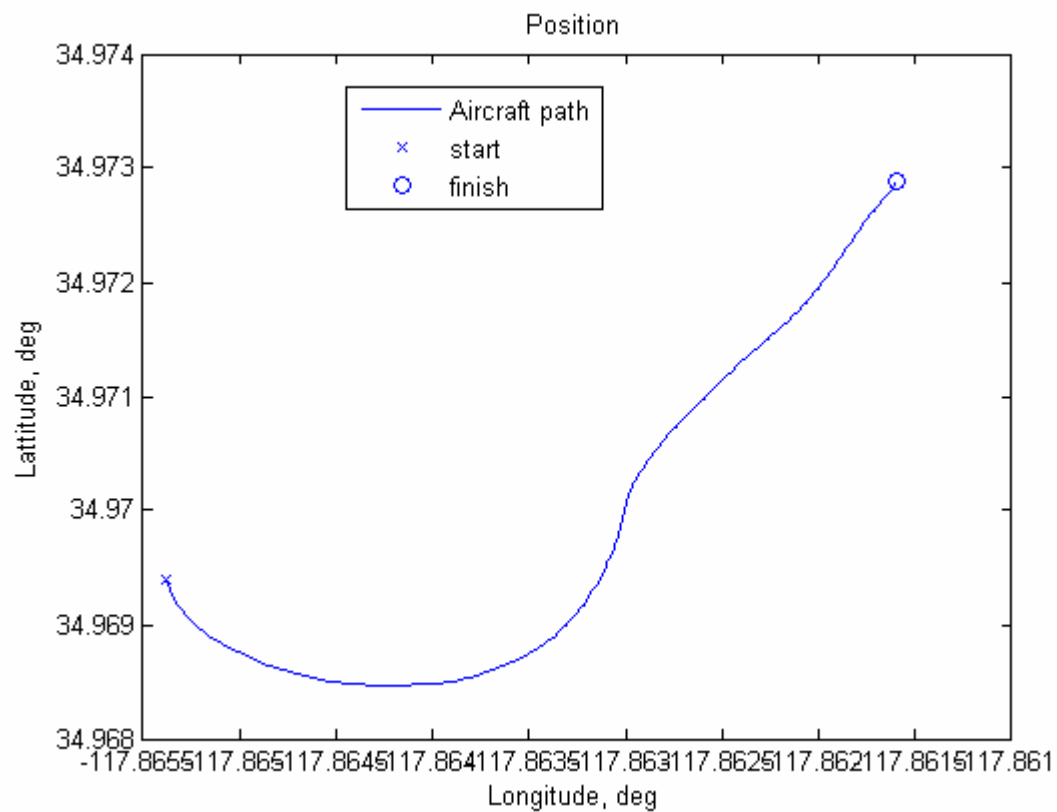


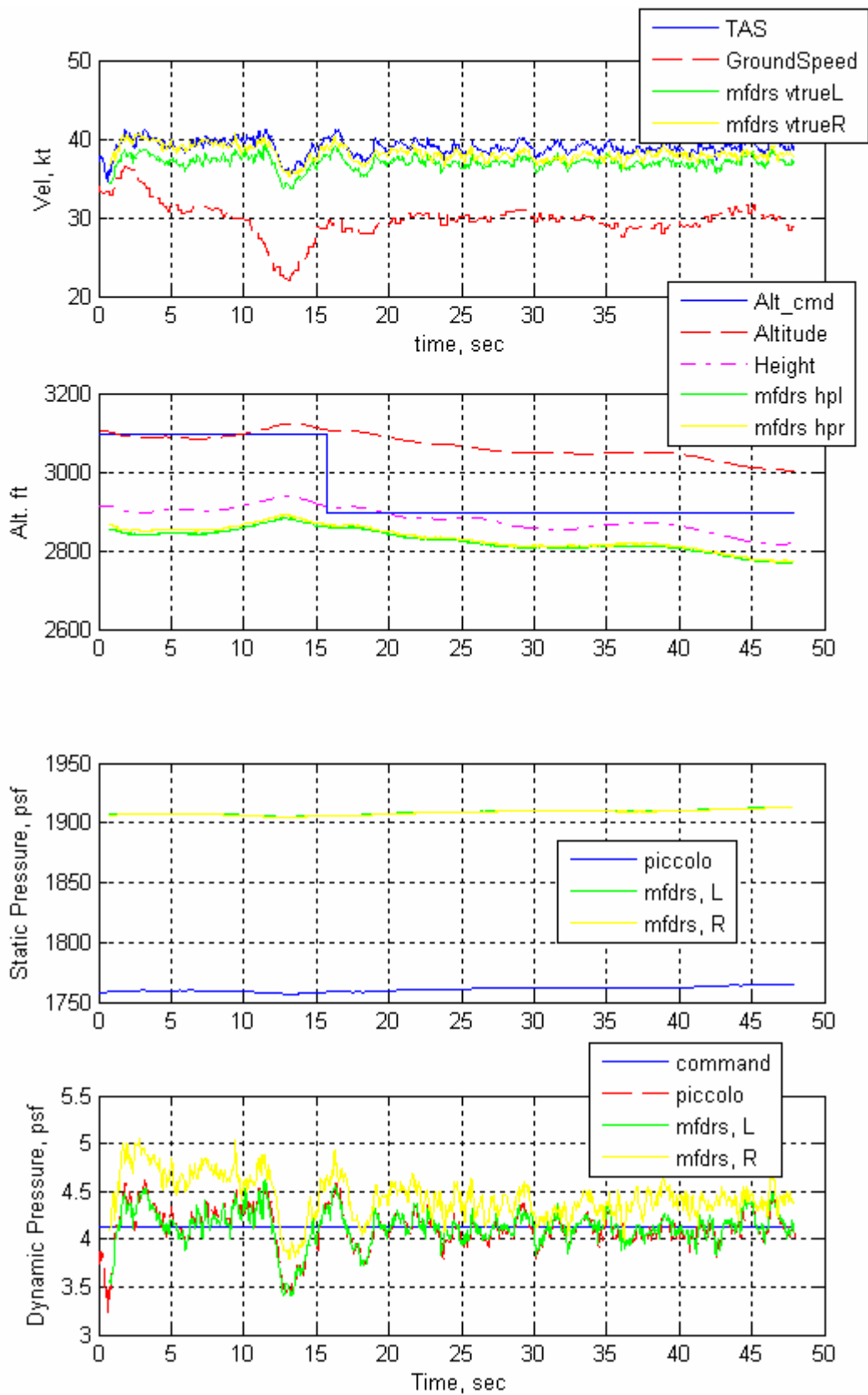


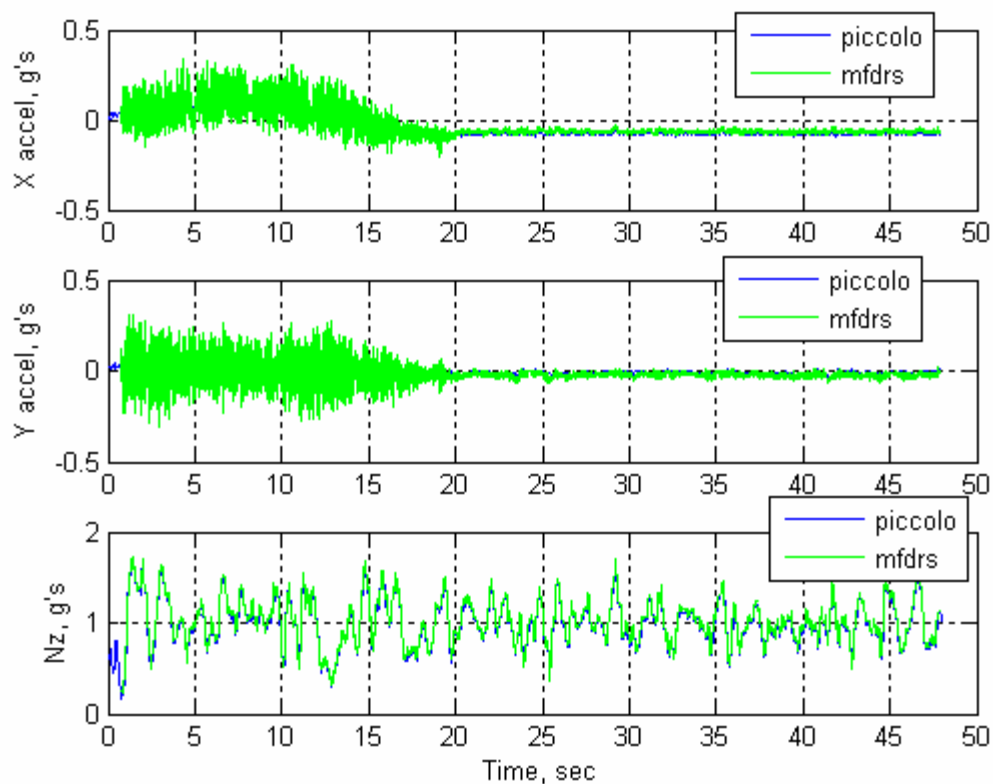
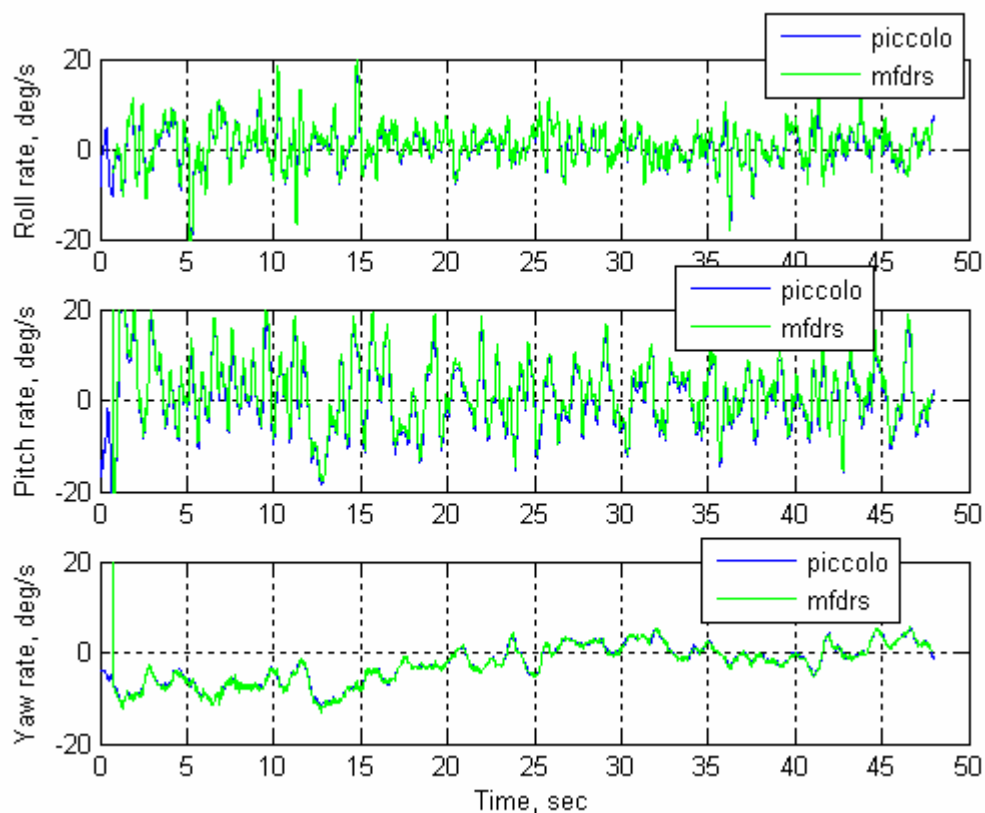


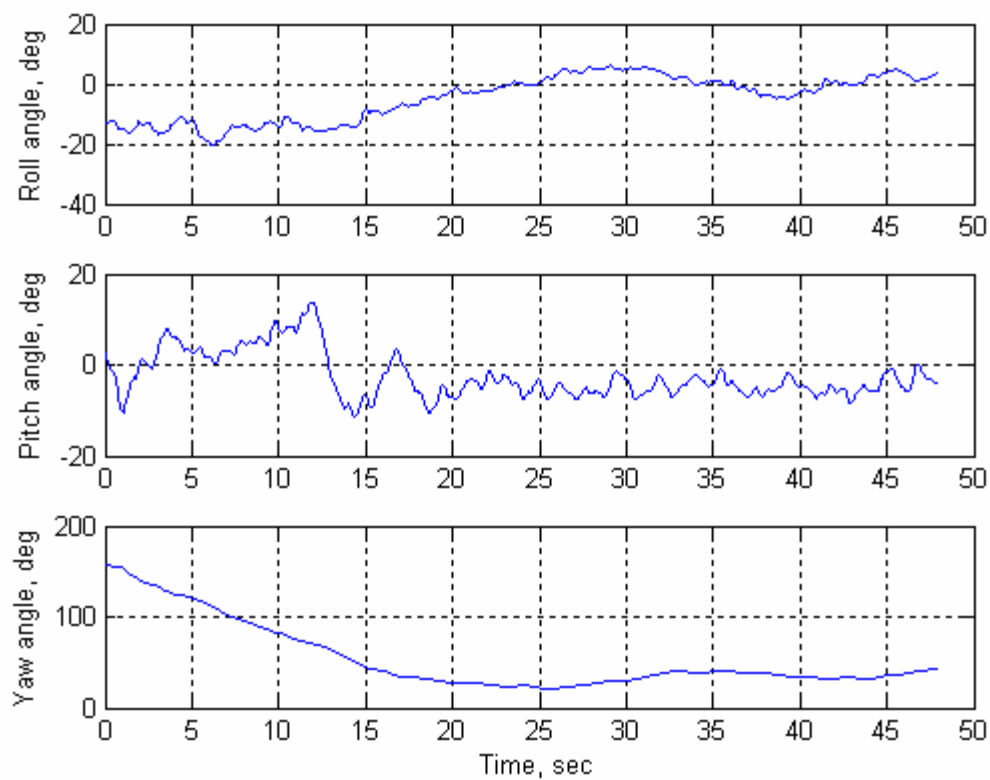
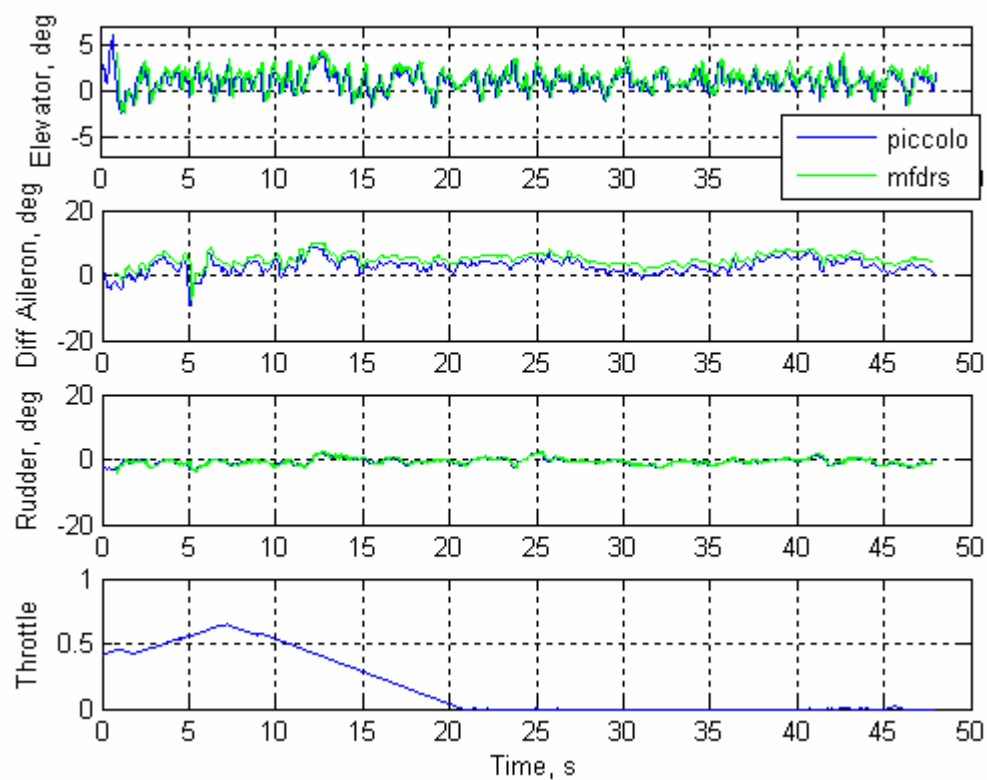


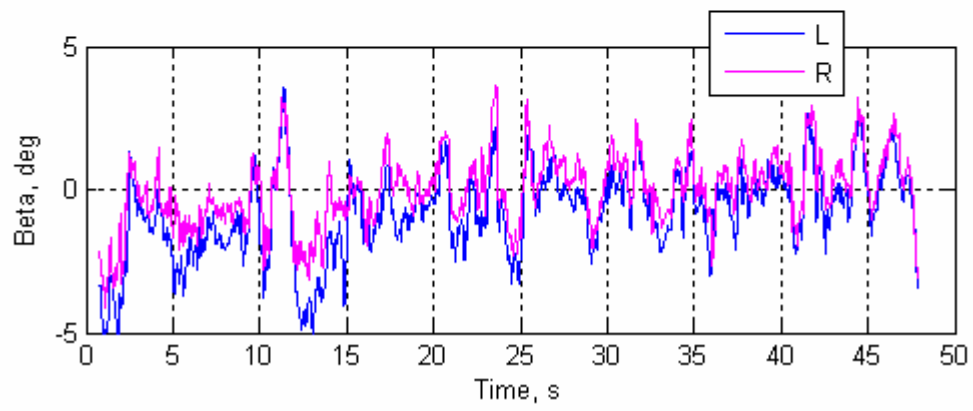
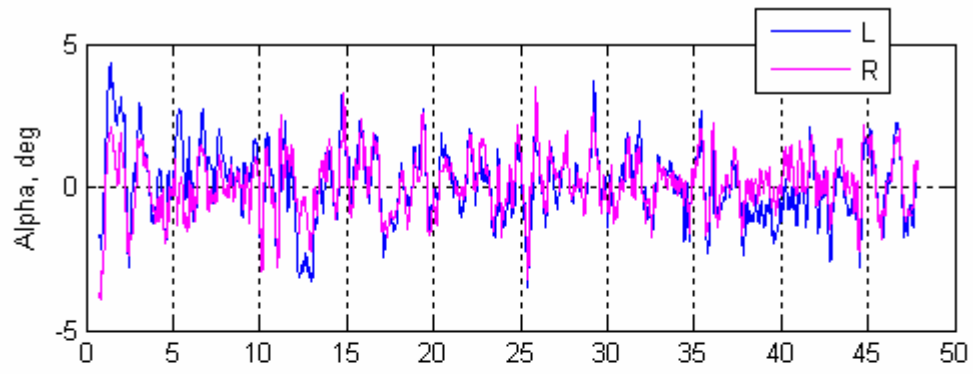
This maneuver provides good data at 40kt with MFDRS data recorded. The first part of the maneuver is corrupted by the motor ramping down to zero and a gentle turn.





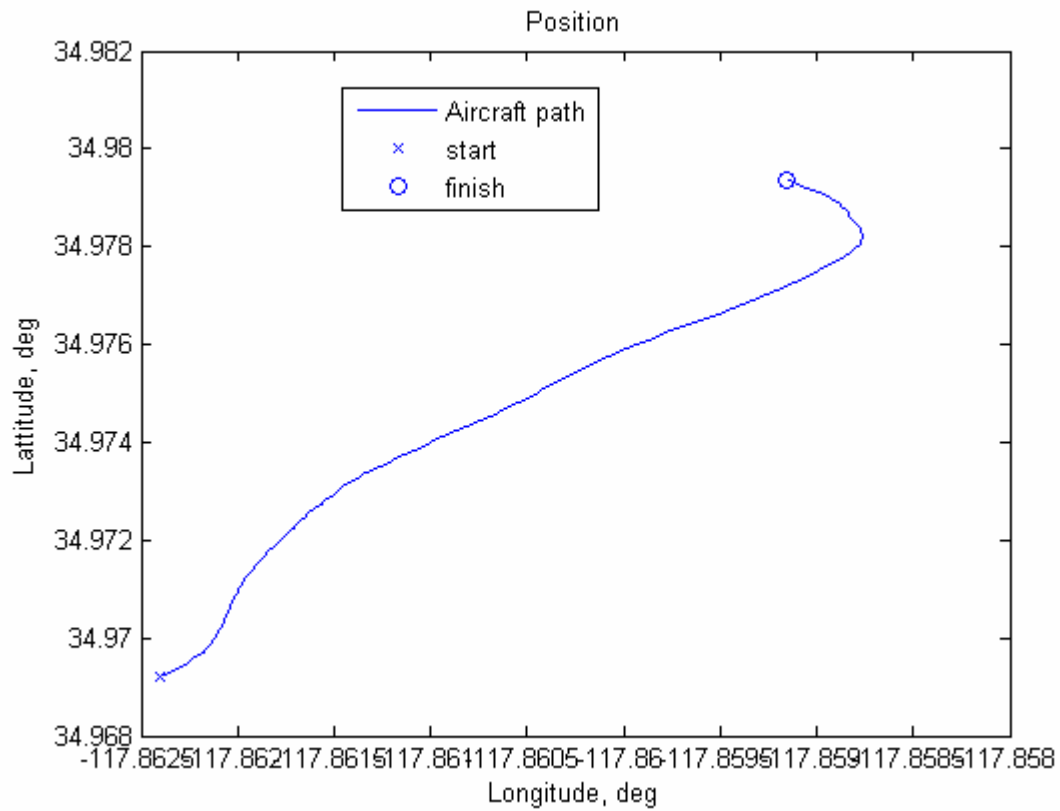


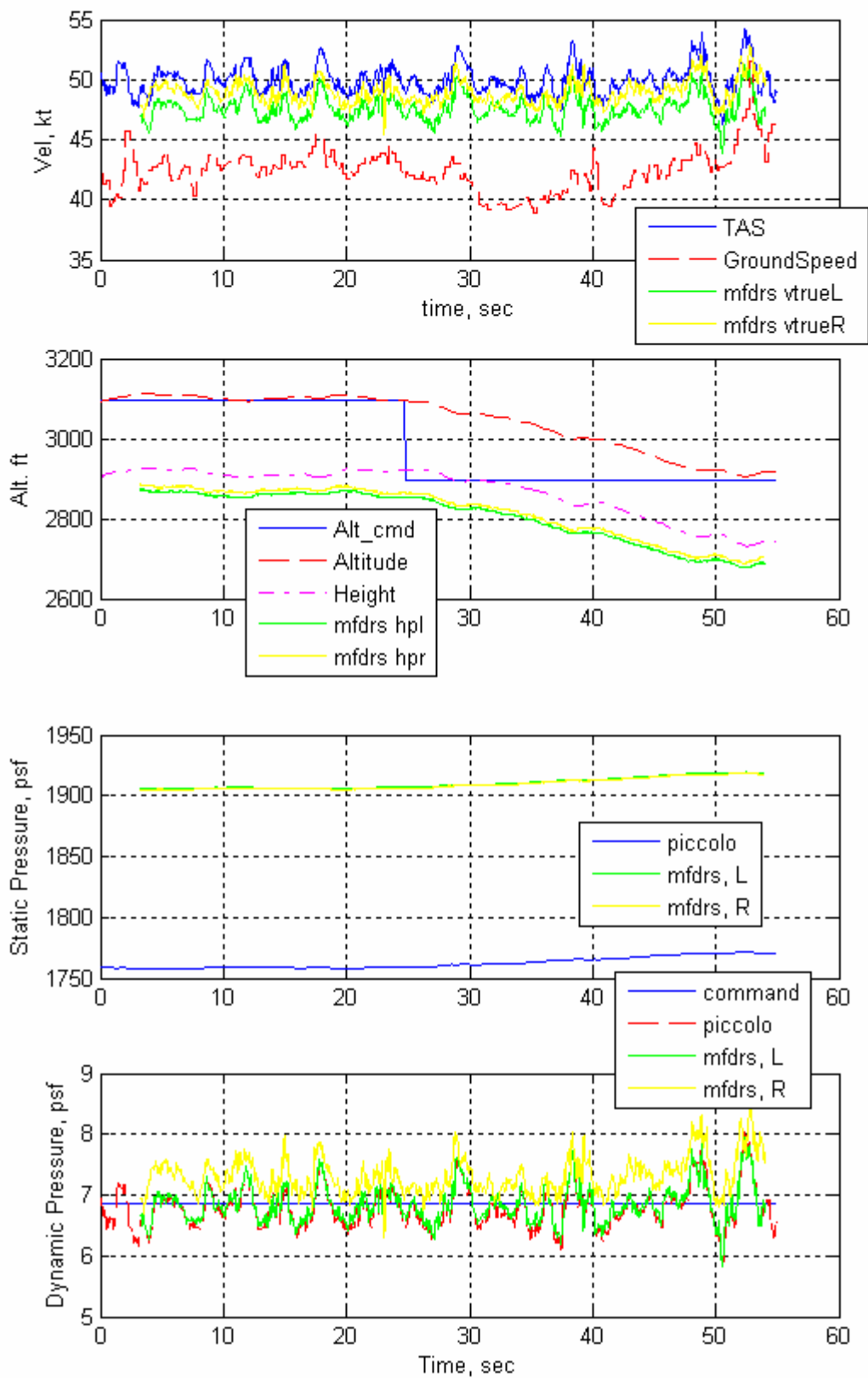


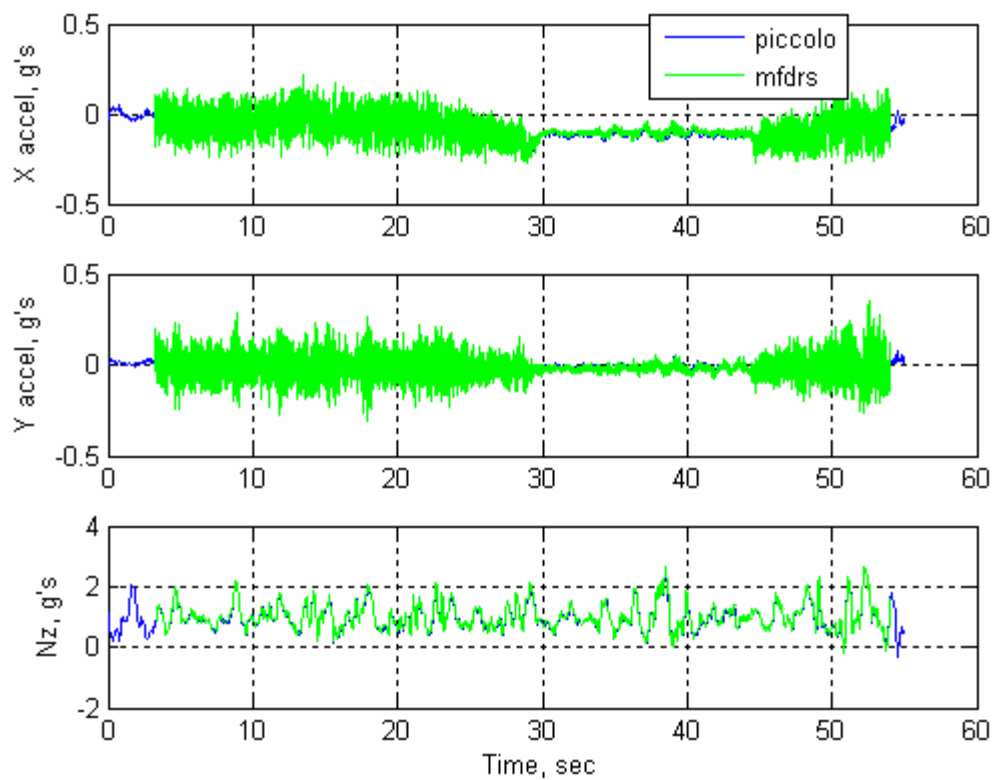
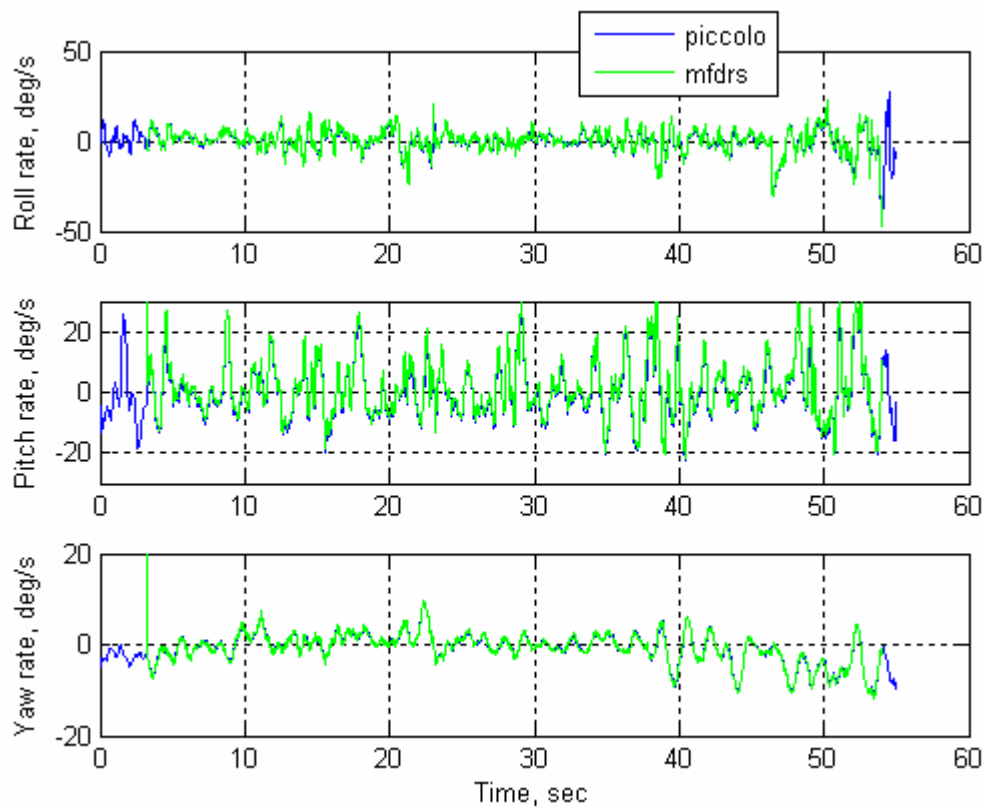


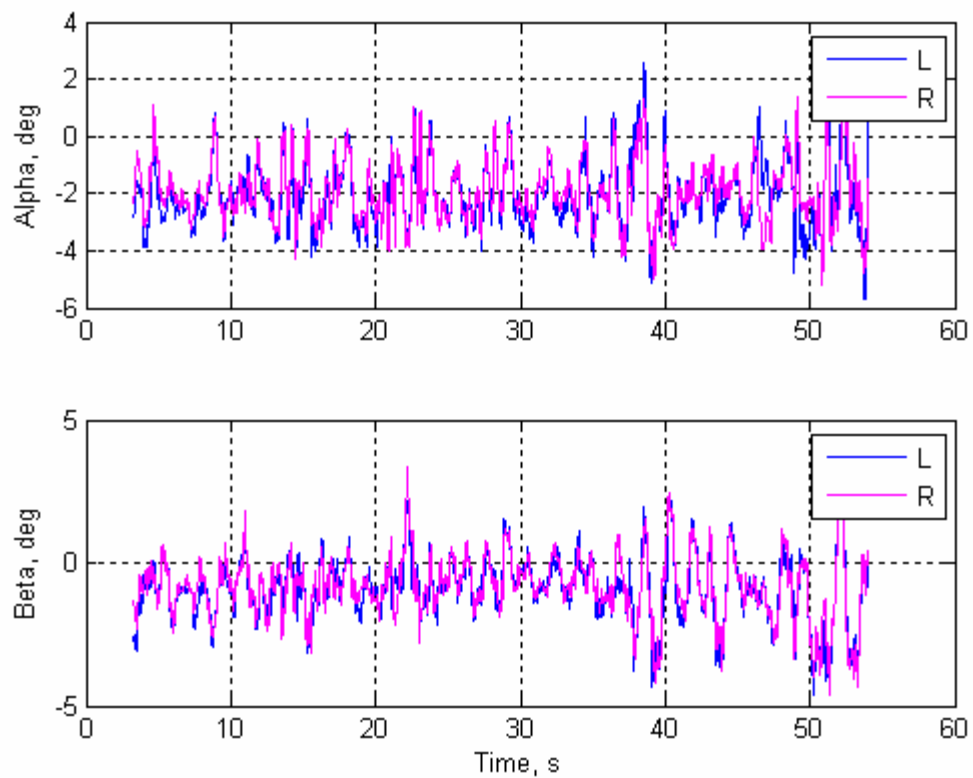
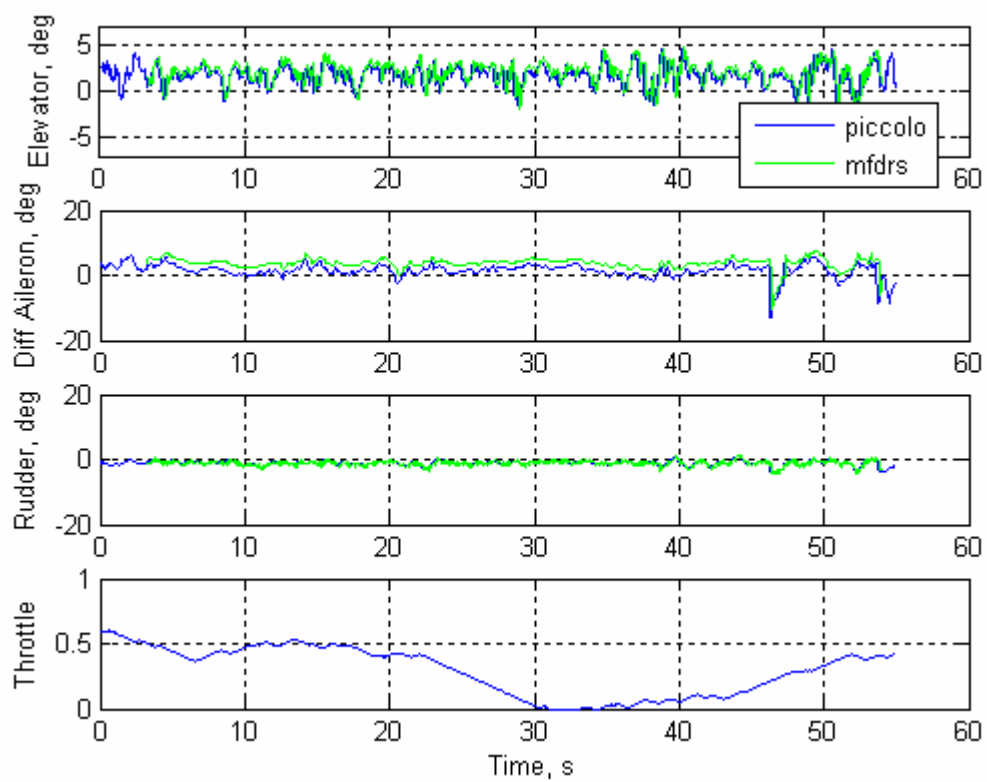
1.5.2 50kt Glide

The 50kt data includes MFDRS data but is of limited use for determining the speed polar because the motor was on for all but 10sec of the maneuver and actually never went to all the way to zero.



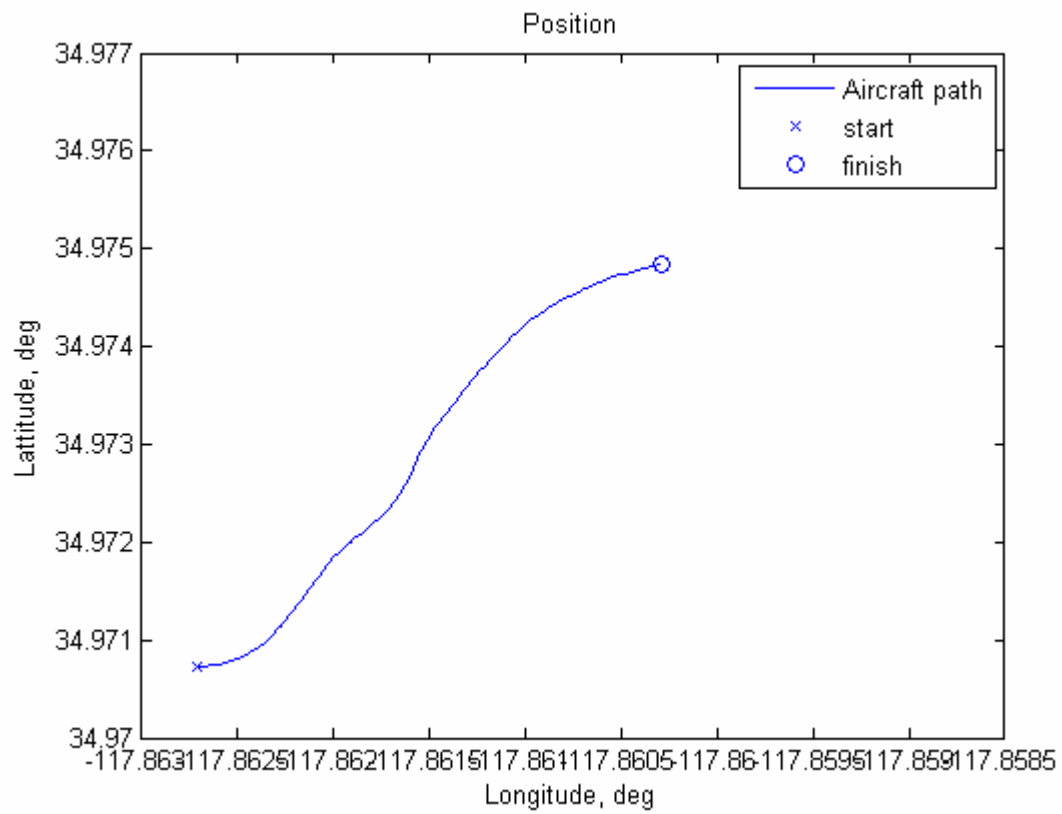


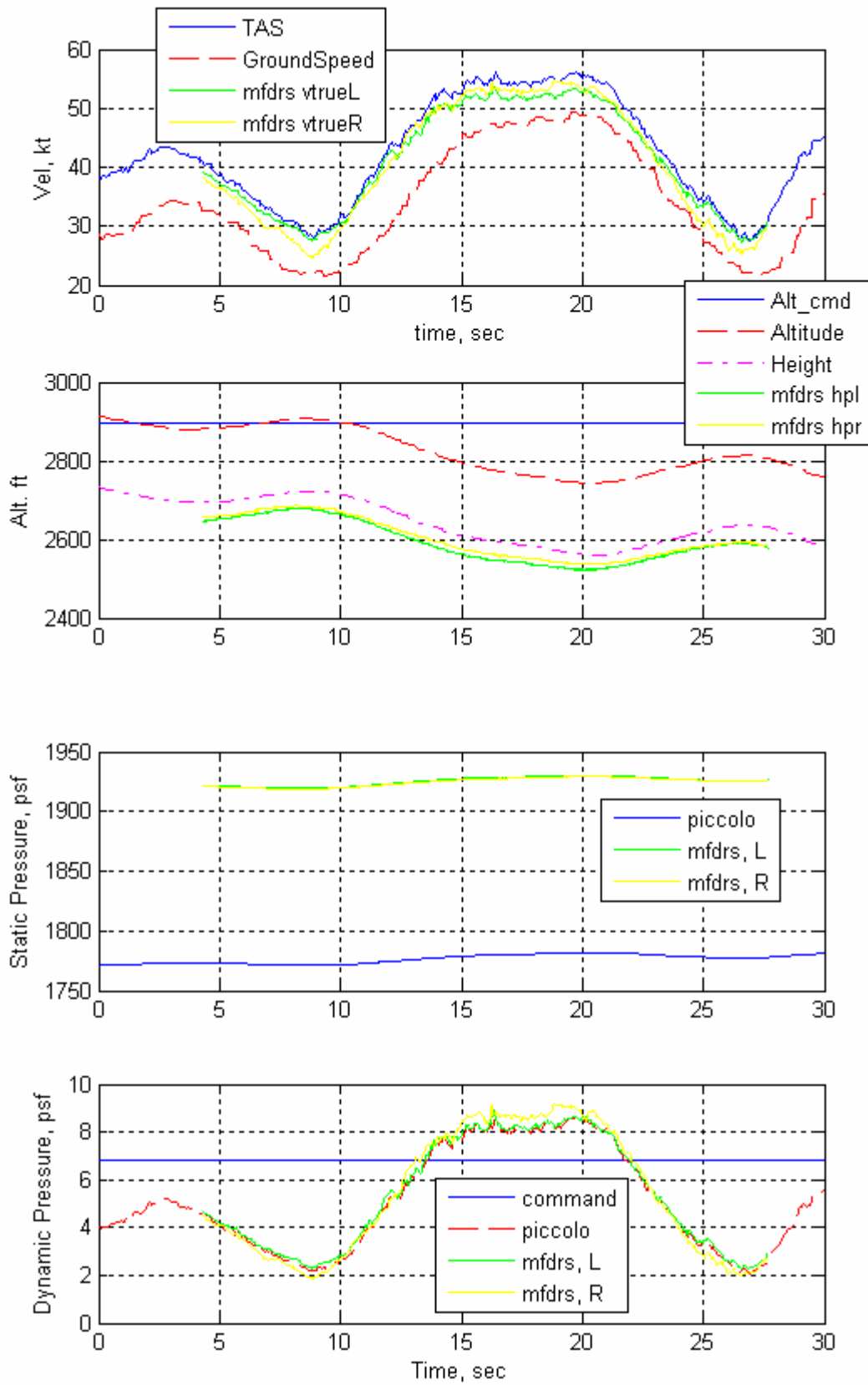


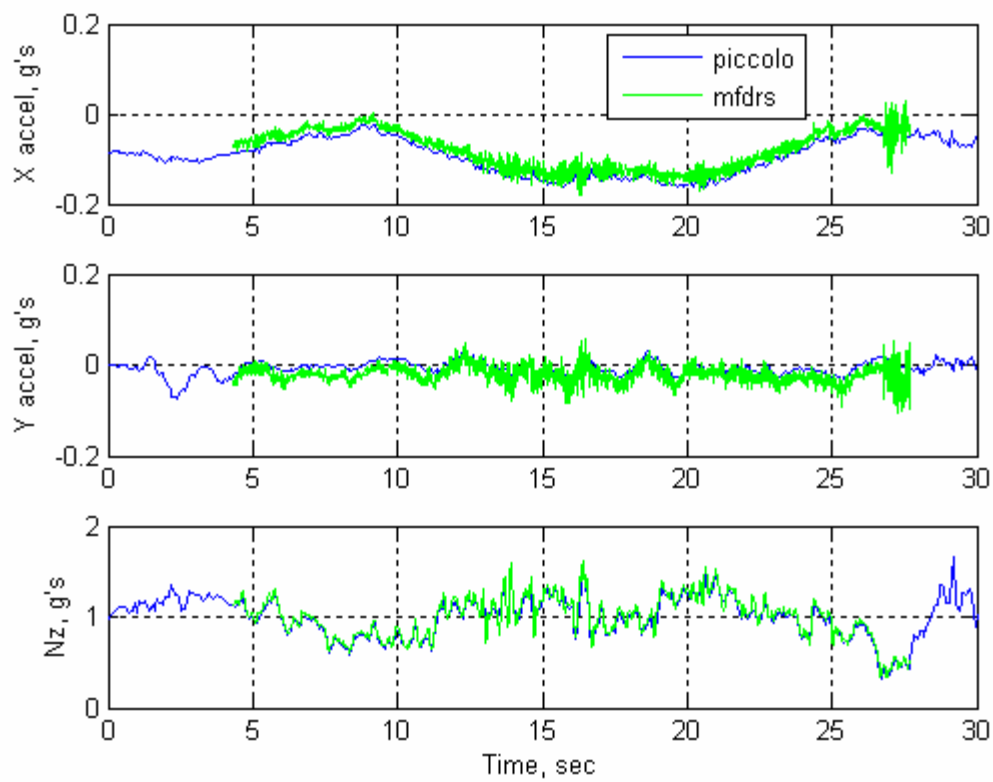
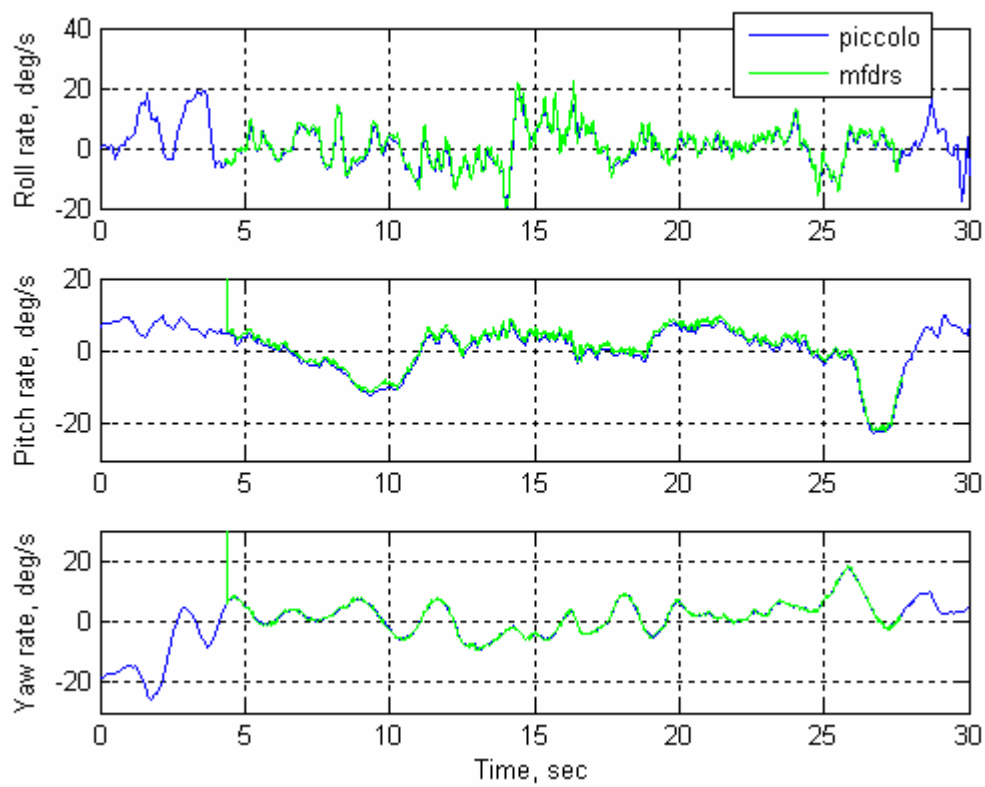


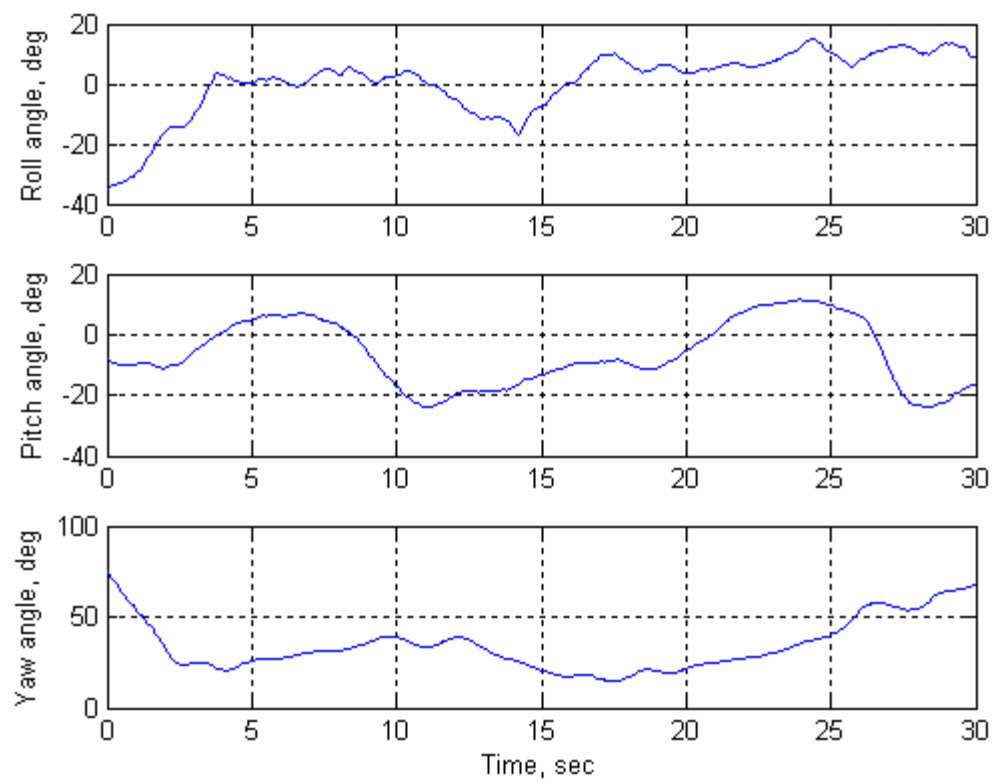
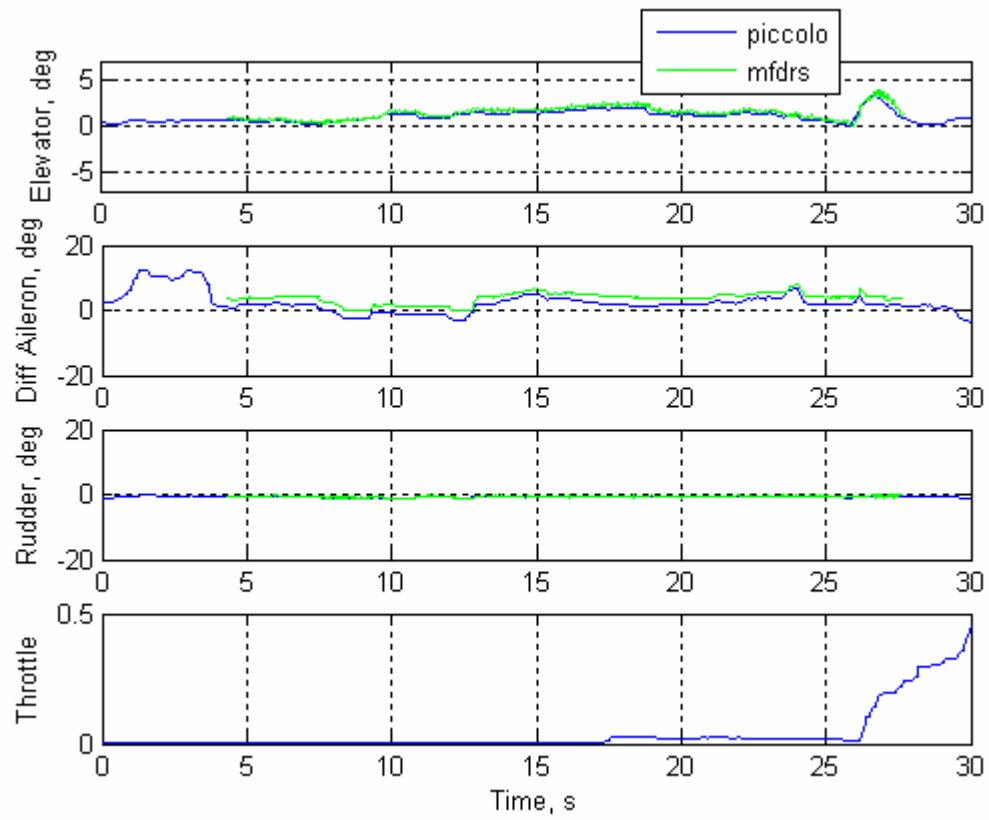
1.5.3 POPU 1

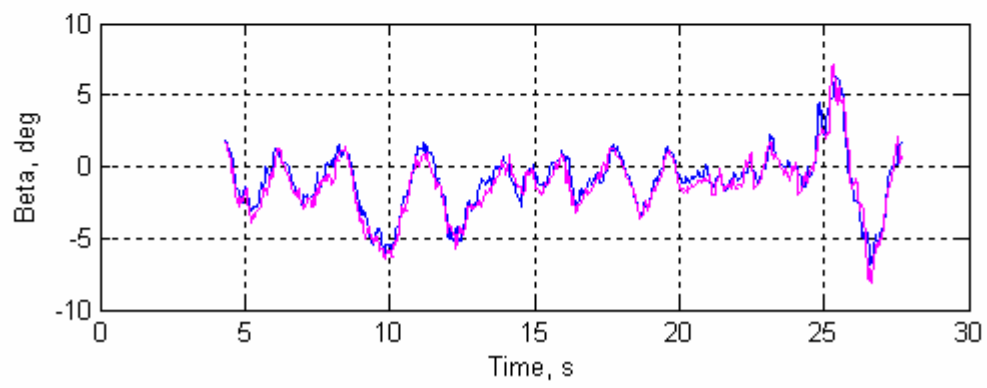
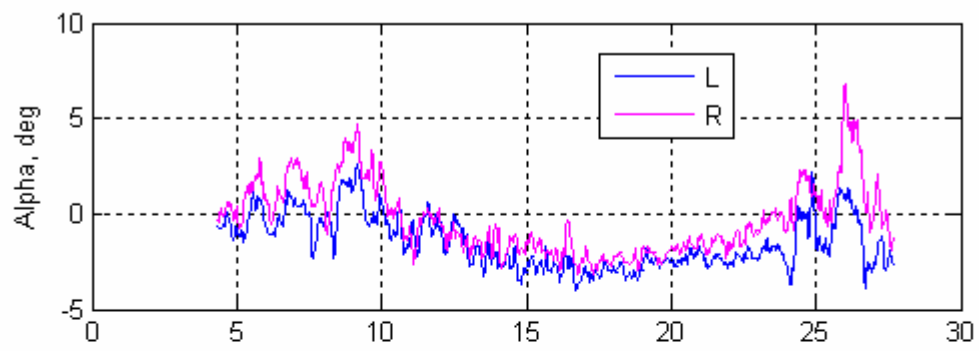
This data shows a piloted pitch over – pull up maneuver.





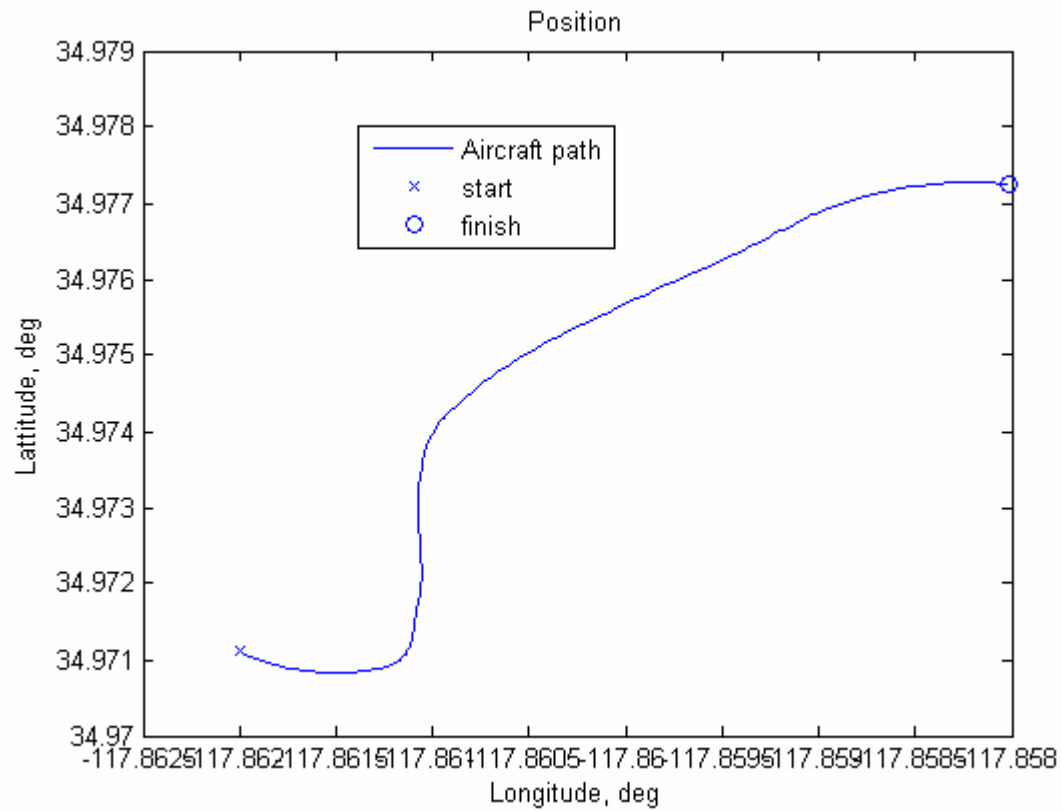


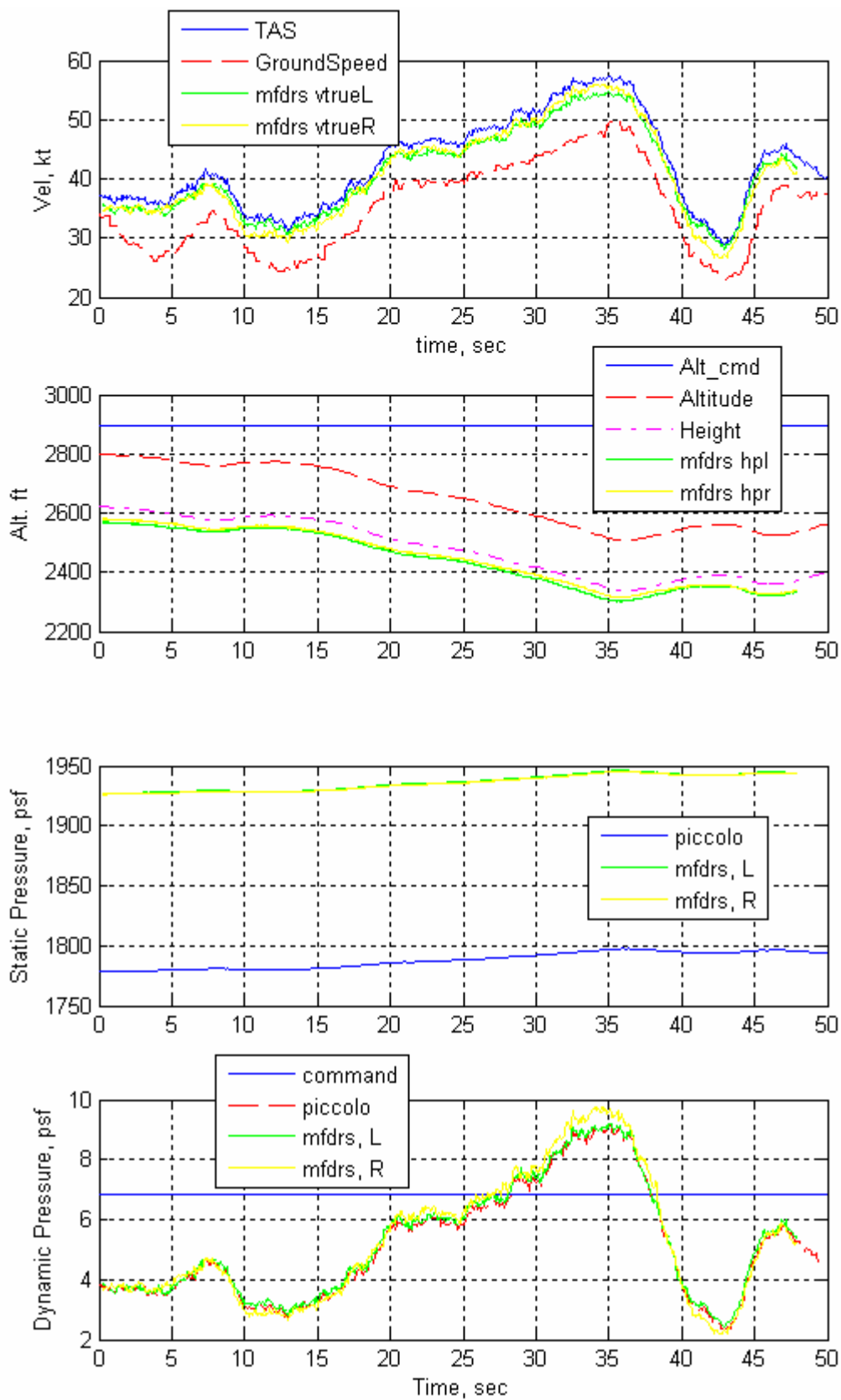


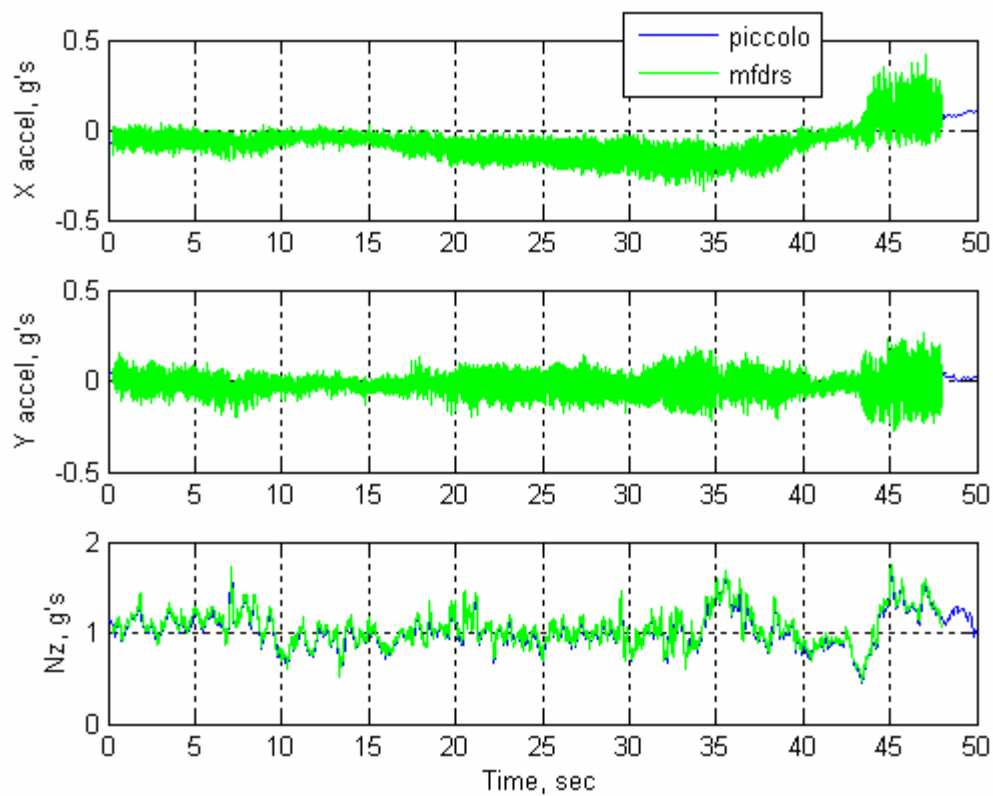
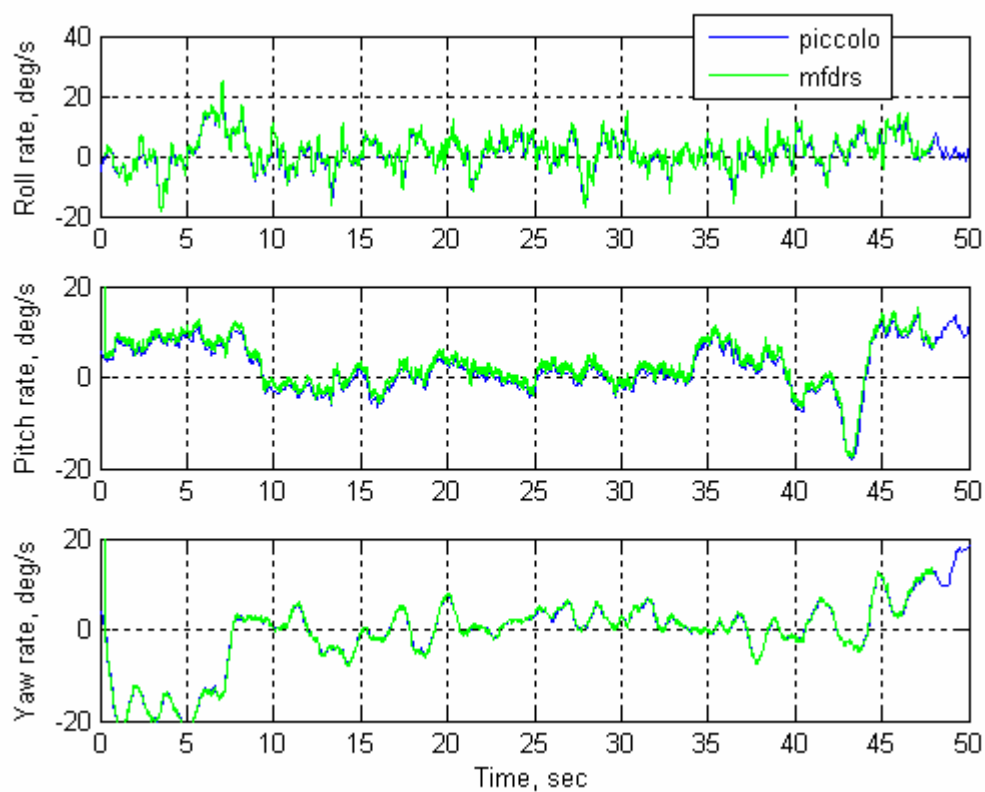


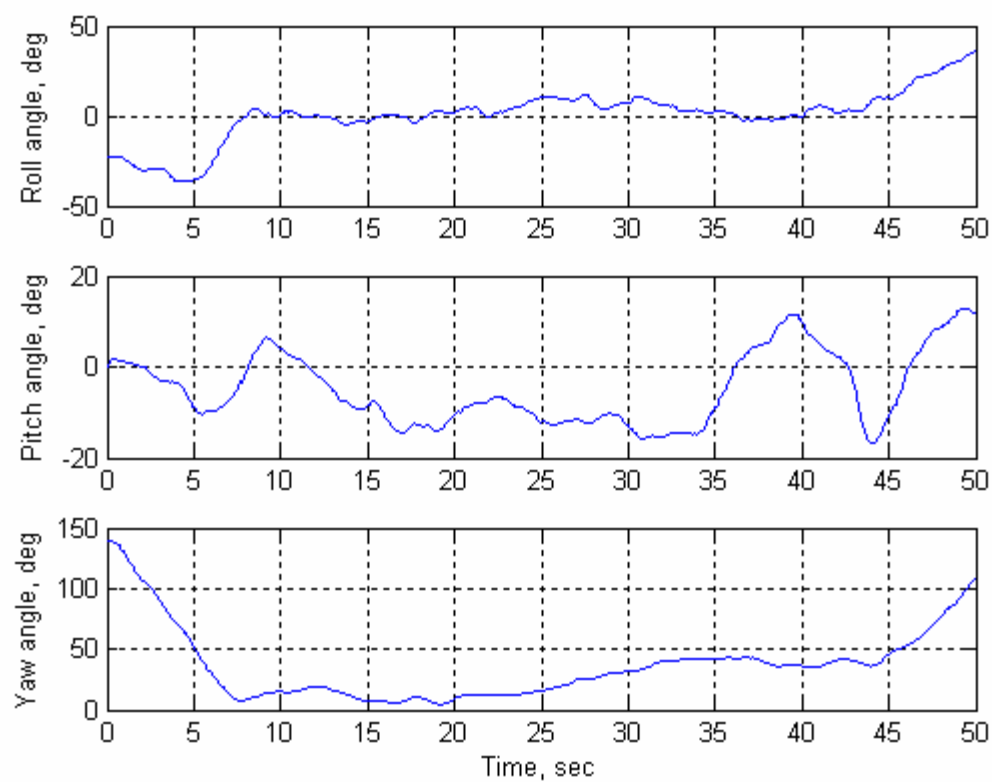
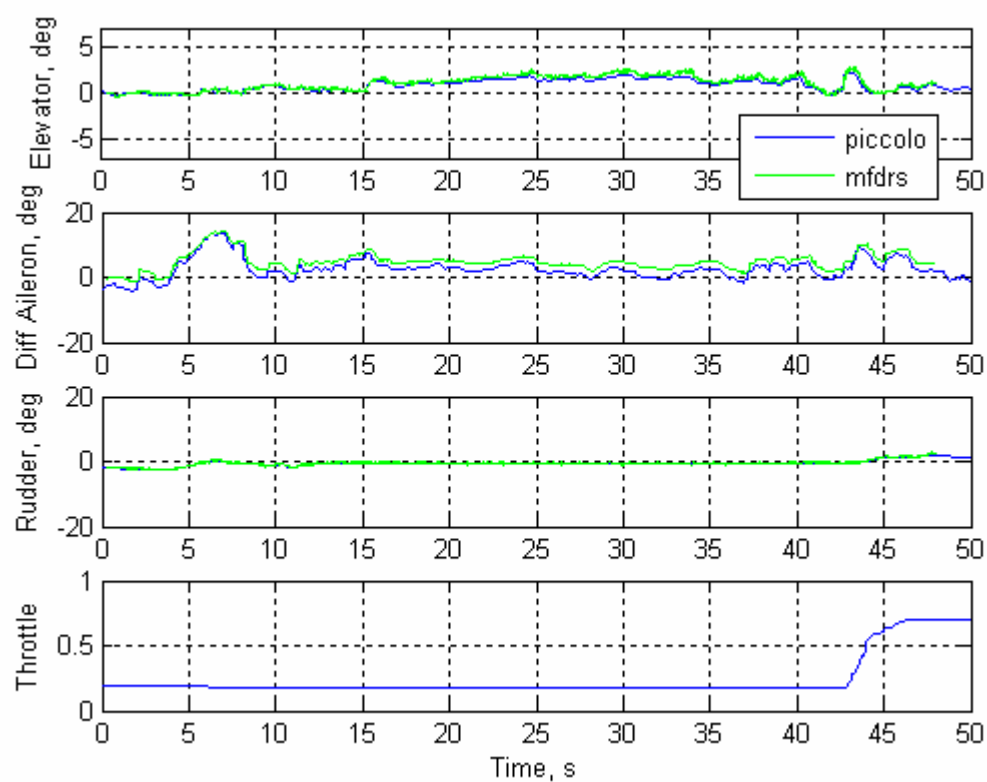
1.5.4 POPU 2

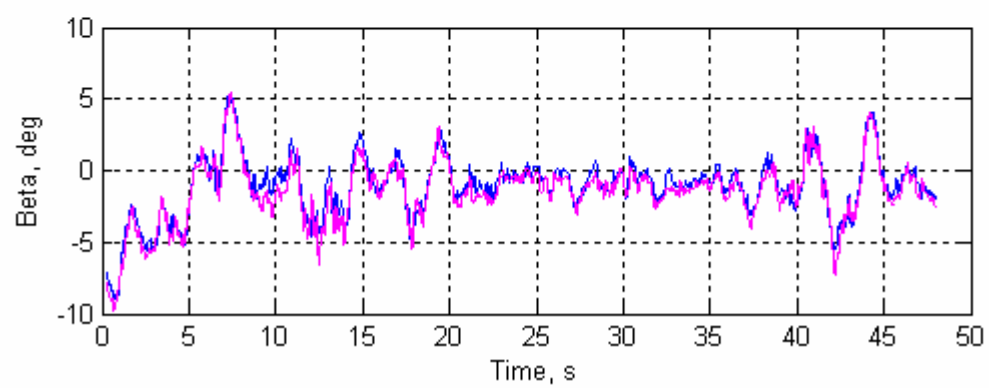
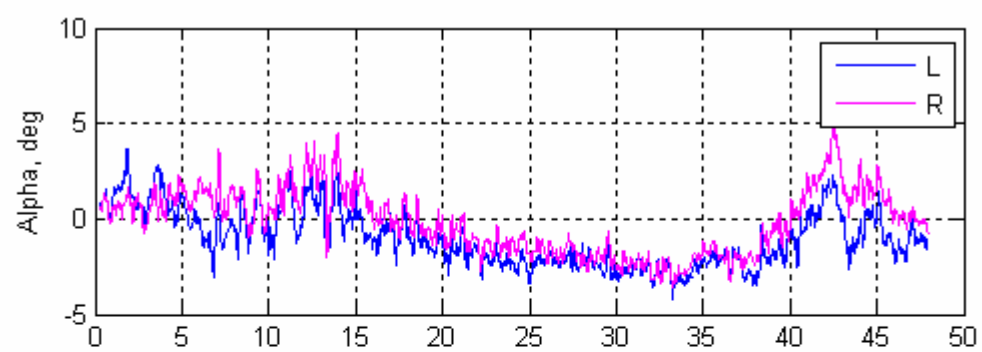
This maneuver was considered better than POPU 1 when it was conducted but closer inspection revealed that the pilot had left the throttle on during the maneuver.





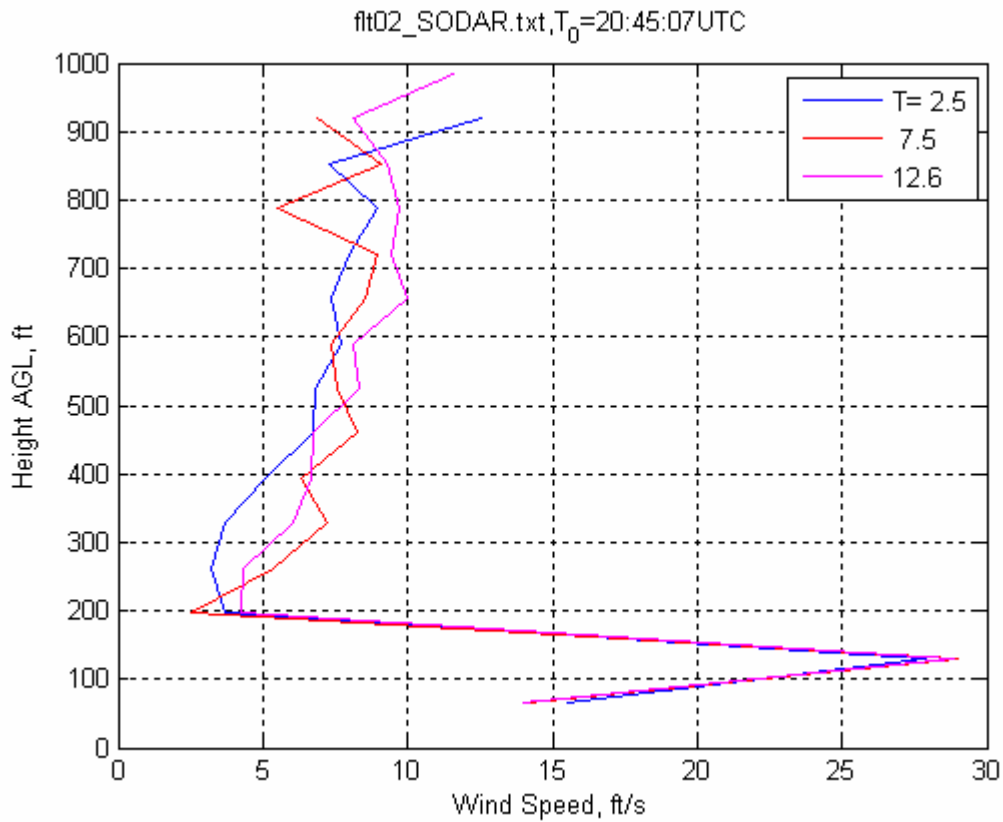


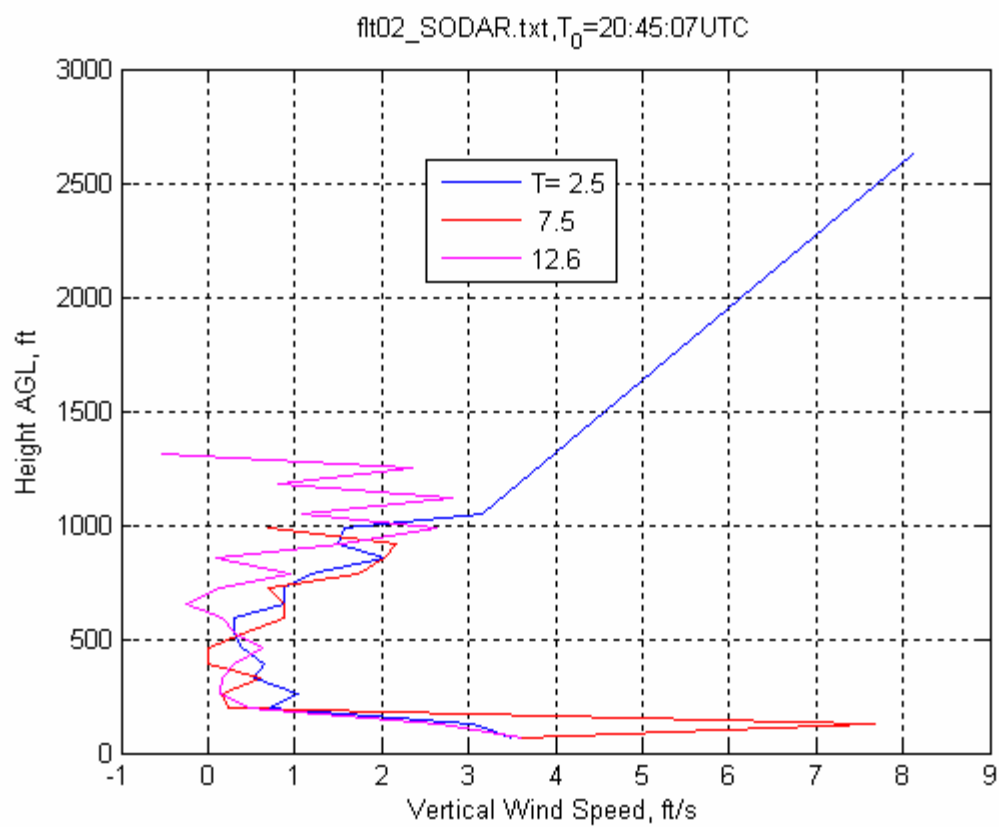
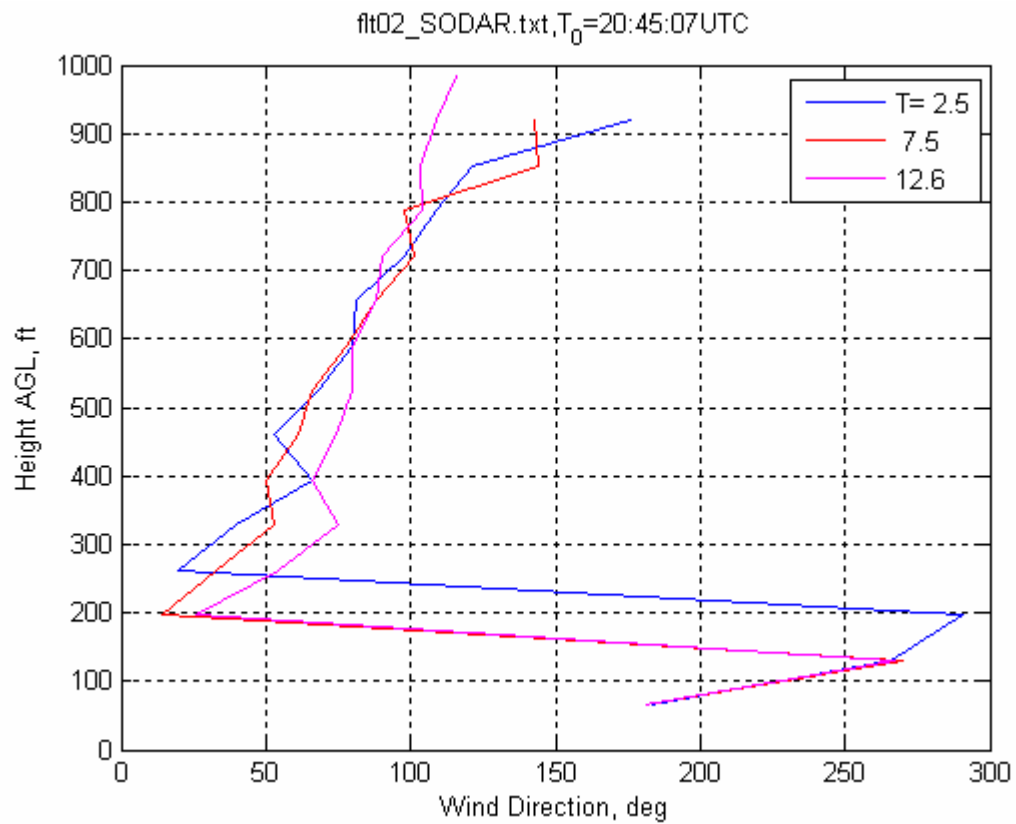


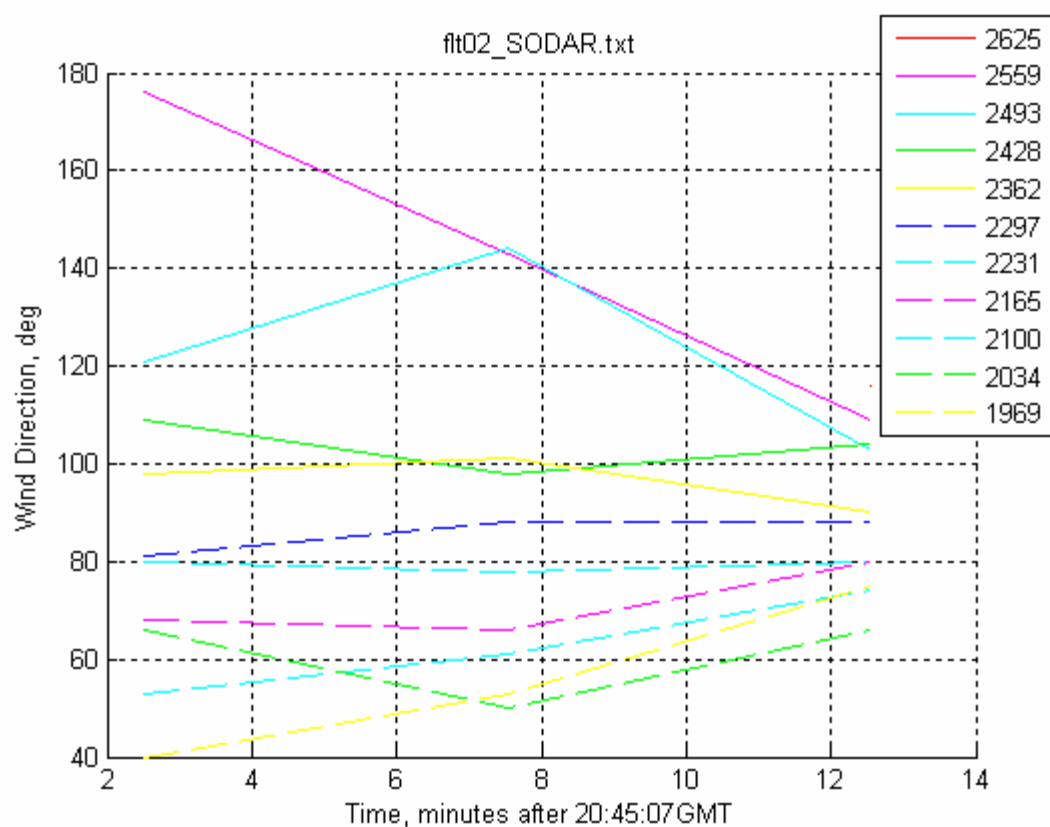
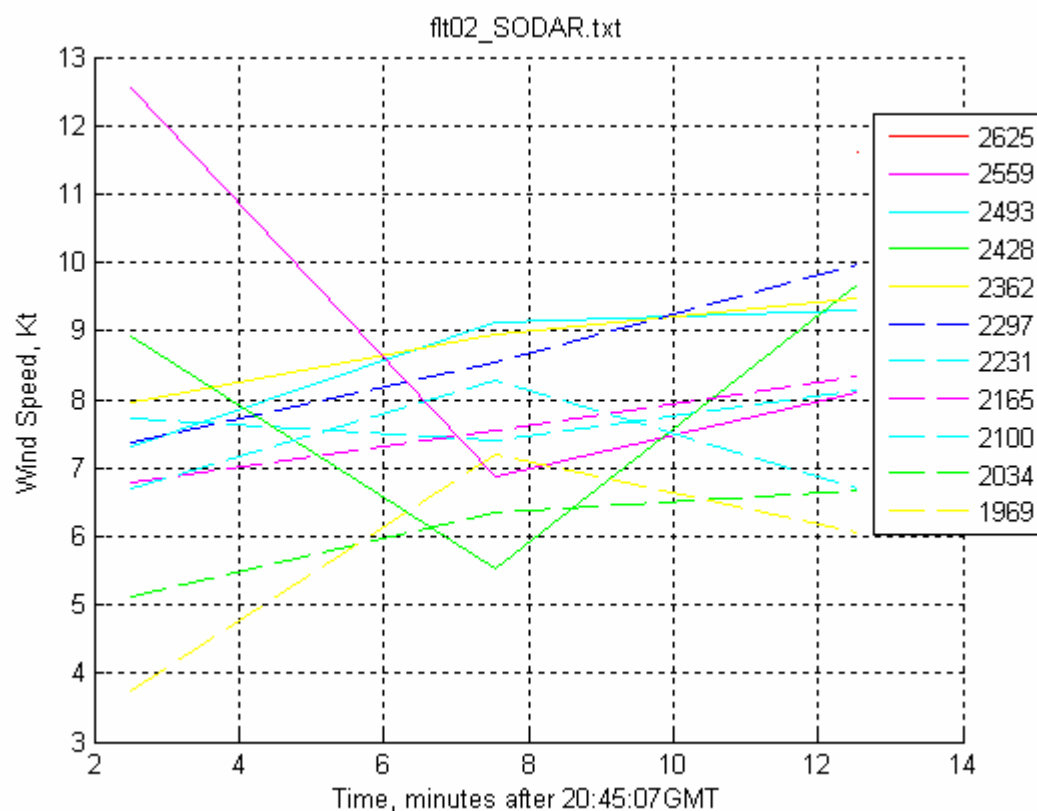


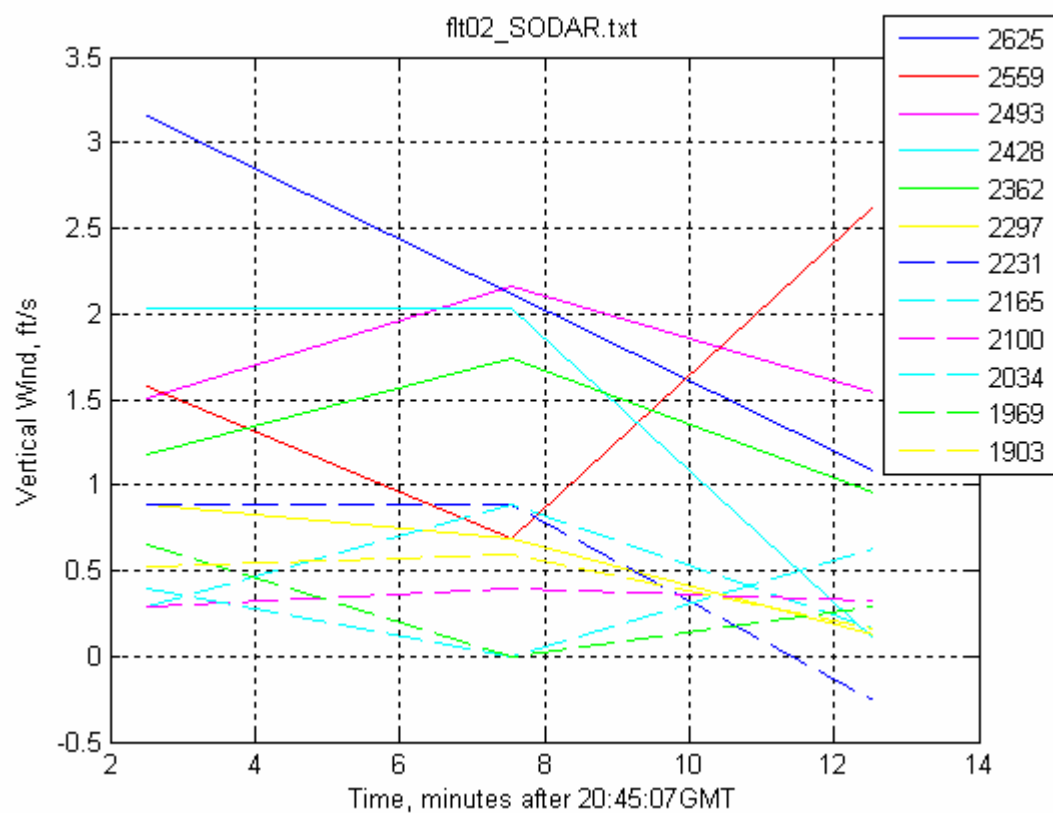
1.5.5 SODAR Data

SODAR Data for flight 1 was gathered with the NASA SODAR located on the Northwest edge of the lakebed near the shuttle area. The test location is approximately 2 miles from the SODAR location. Start time for the SODAR data is 12/07/2006 20:45:07.



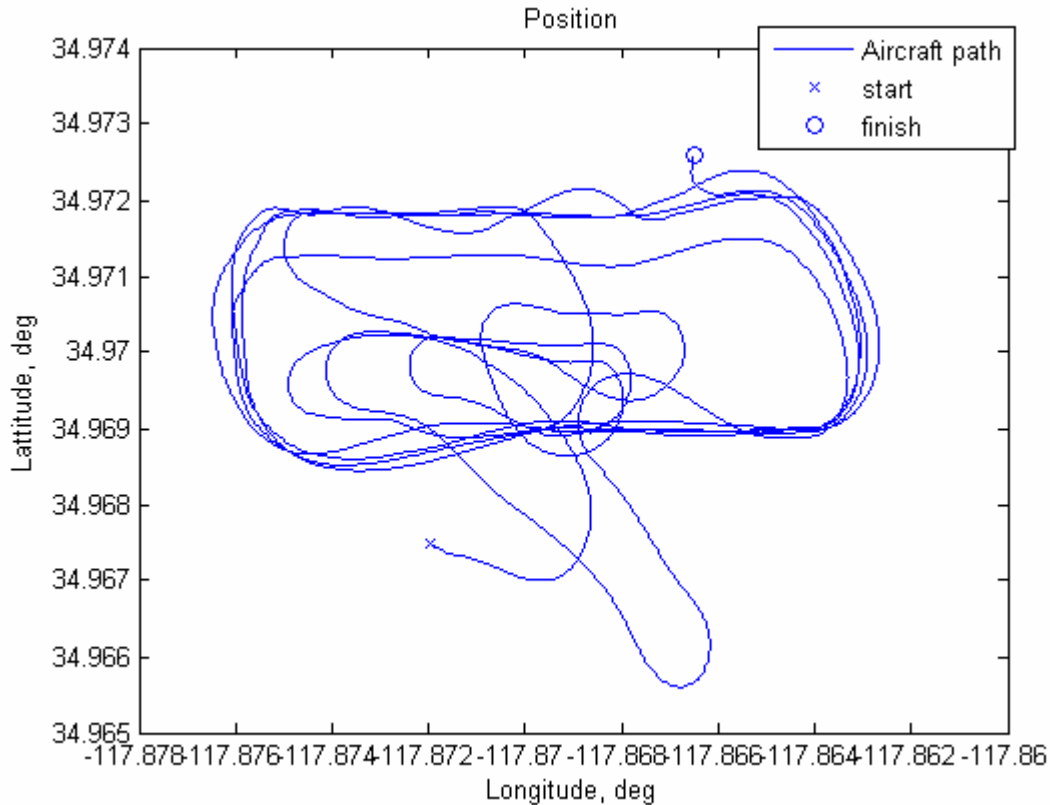


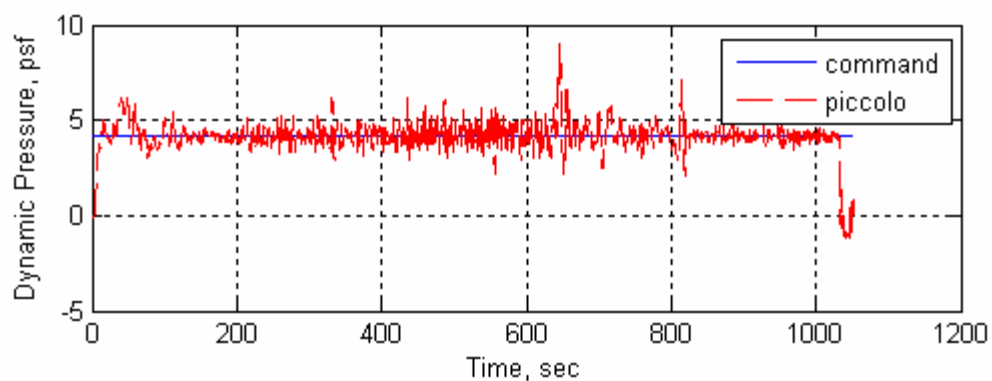
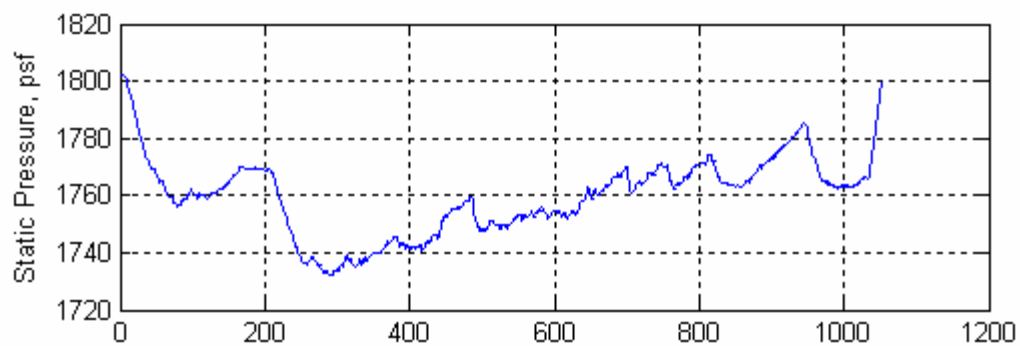
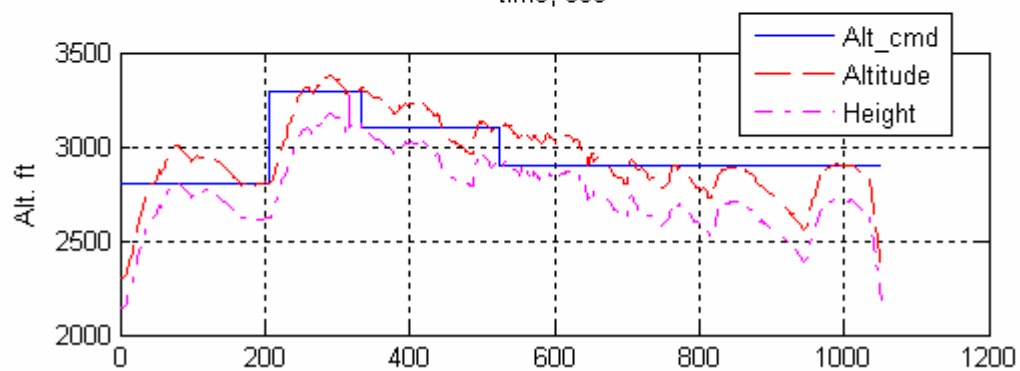
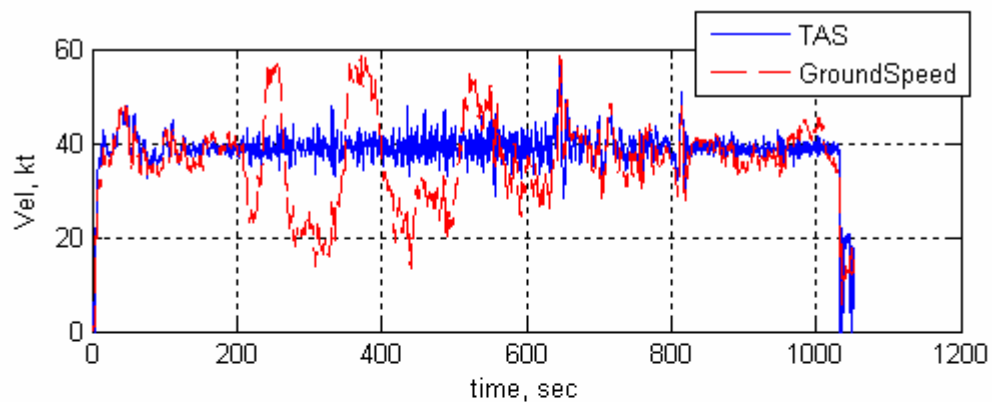


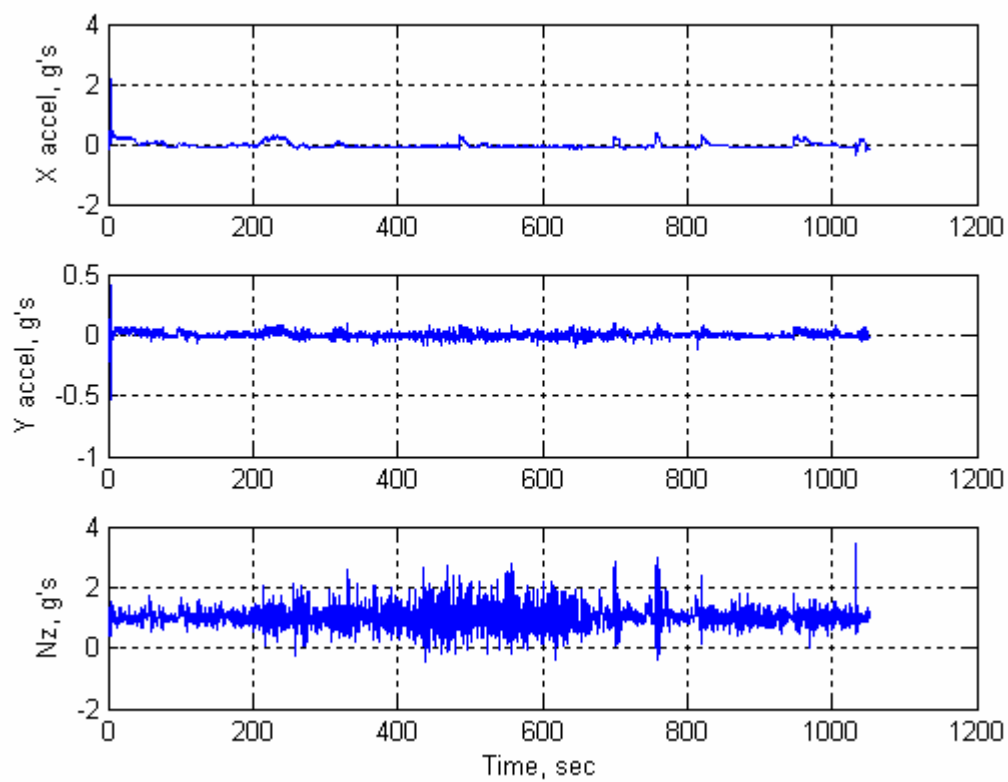
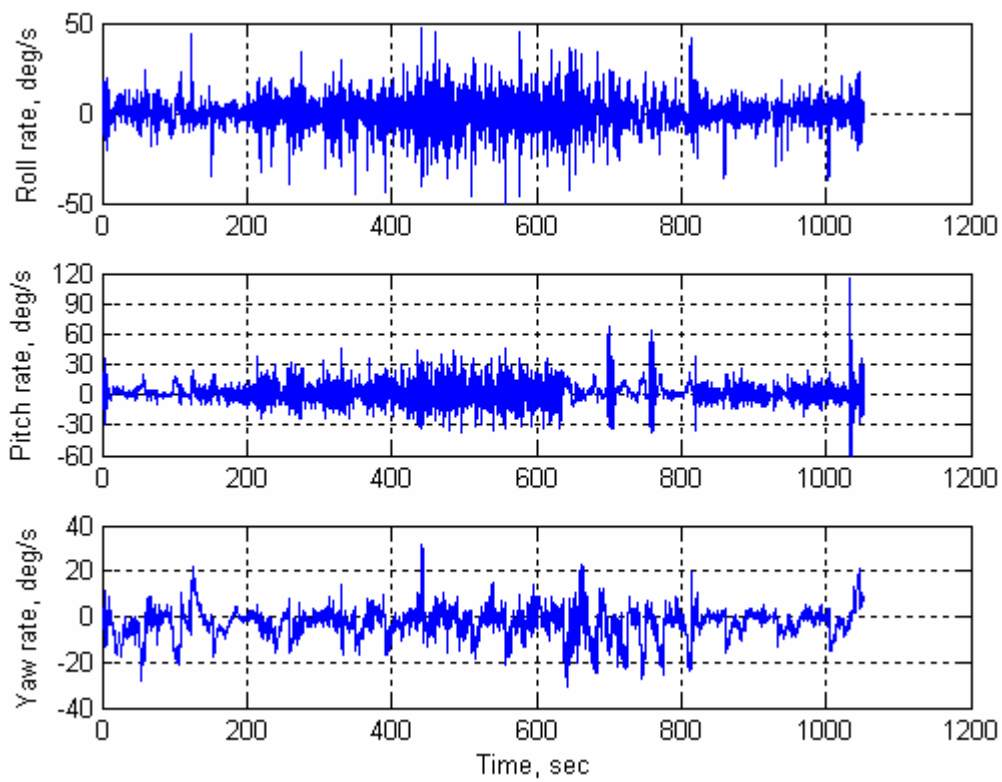


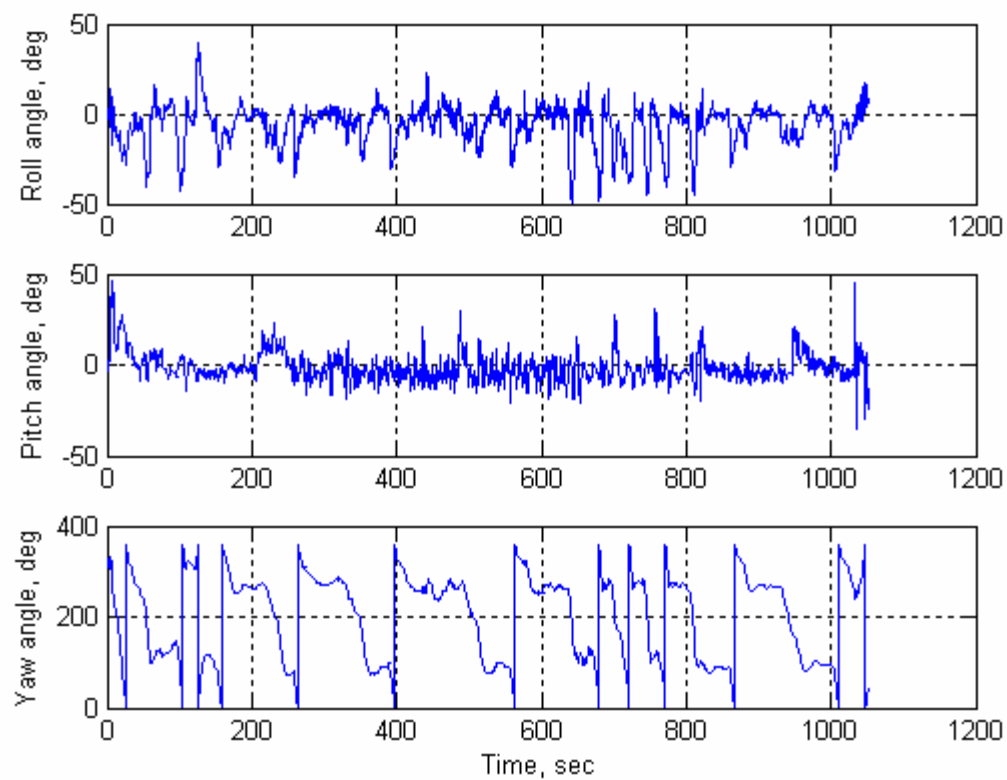
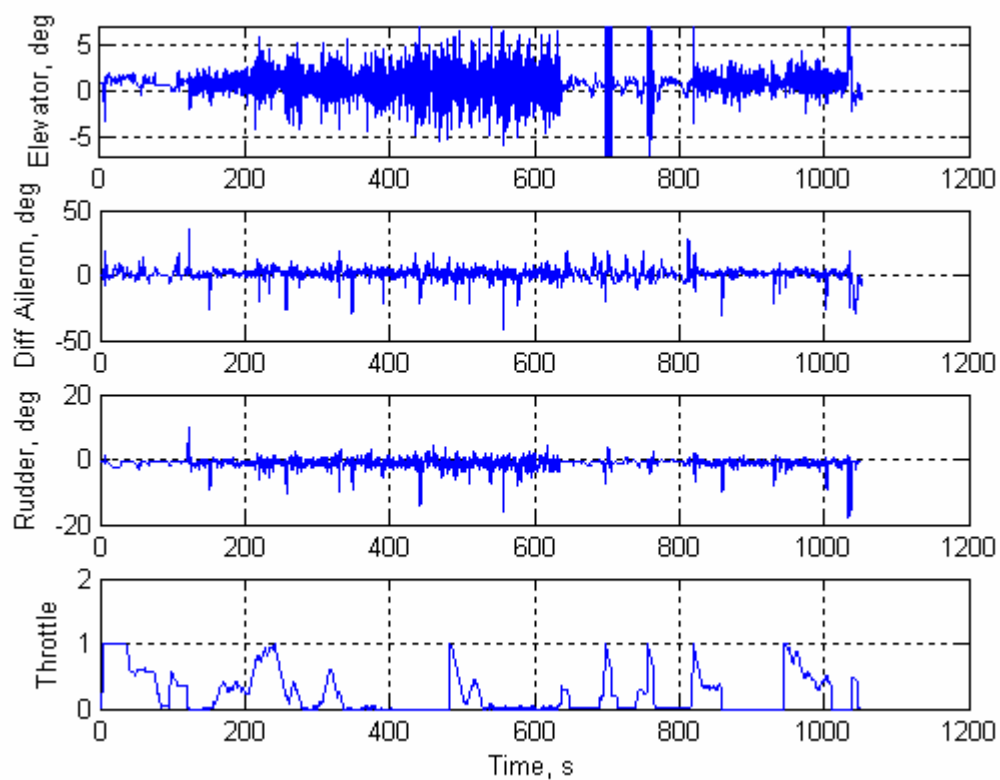
1.6 Cloud Swift 2, Flight 3.

Flight 3 was conducted on December 14, 2006 from 23:01 to 23:19 UTC (3:01pm – 3:19pm local). Flight 3 was used to do PID maneuvers with the motor directly turned off from the OI instead of using altitude commands and with better doublet settings. Unfortunately, flight 3 ended when the aircraft did an un-commanded FTS deployment. This flight includes some good doublets with MFDRS data and the only deep stall data for a model that I am aware of. Strong wind shear and turbulence was encountered during this flight. Note the 2g X-acceleration during launch. New gains were tried at 700-800 seconds which caused the airplane to do large limit cycle pitch oscillations.



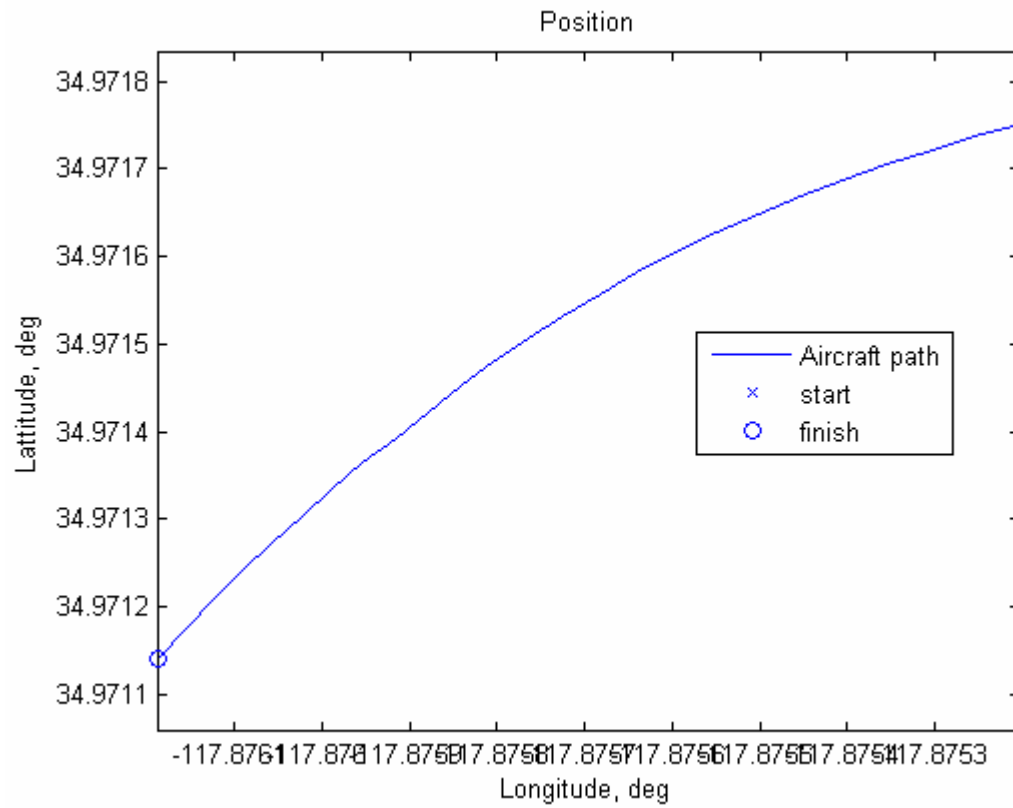


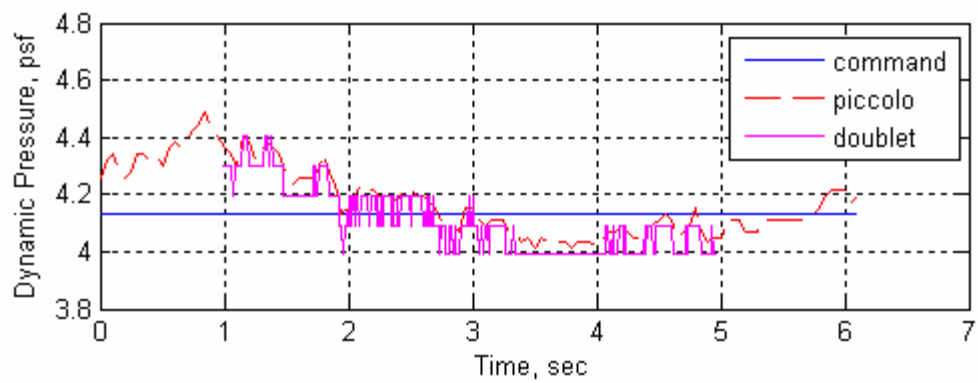
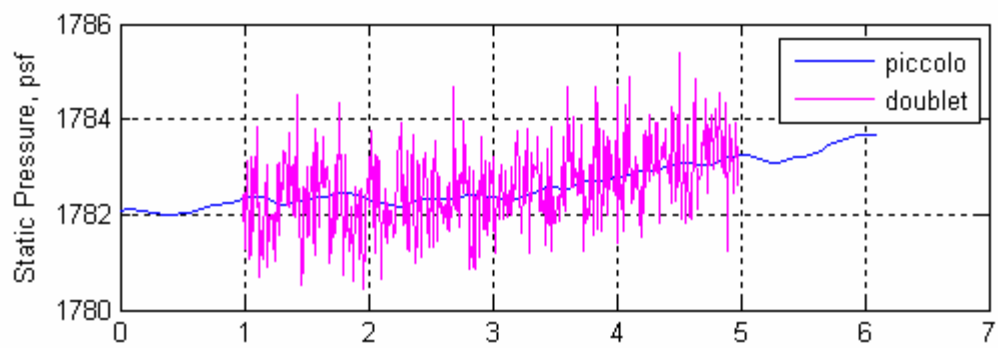
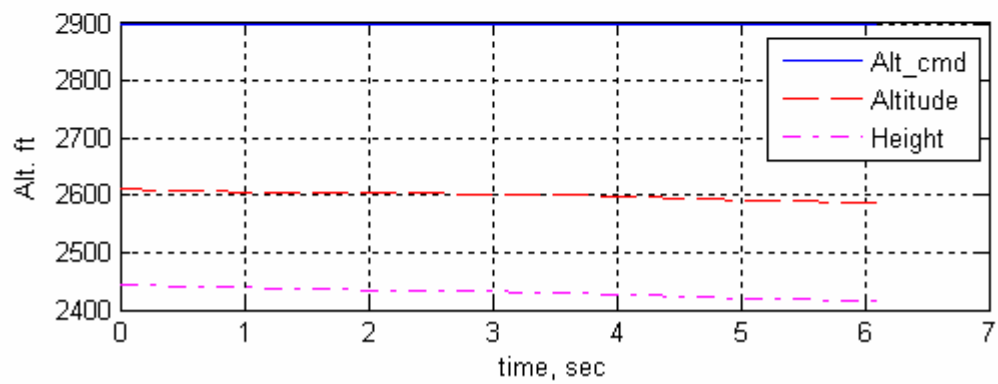
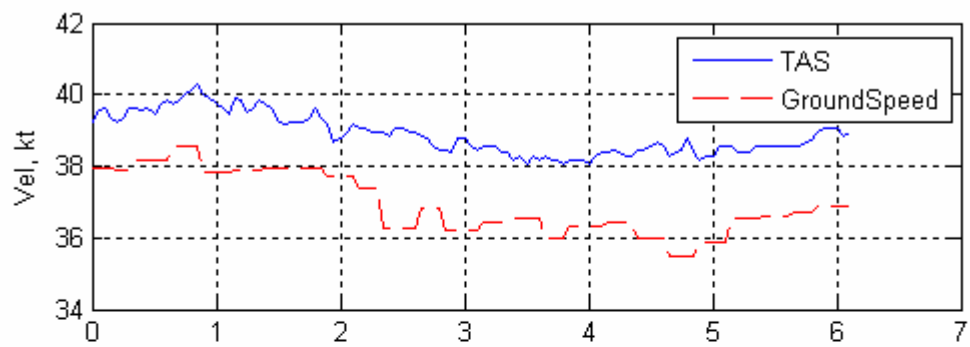


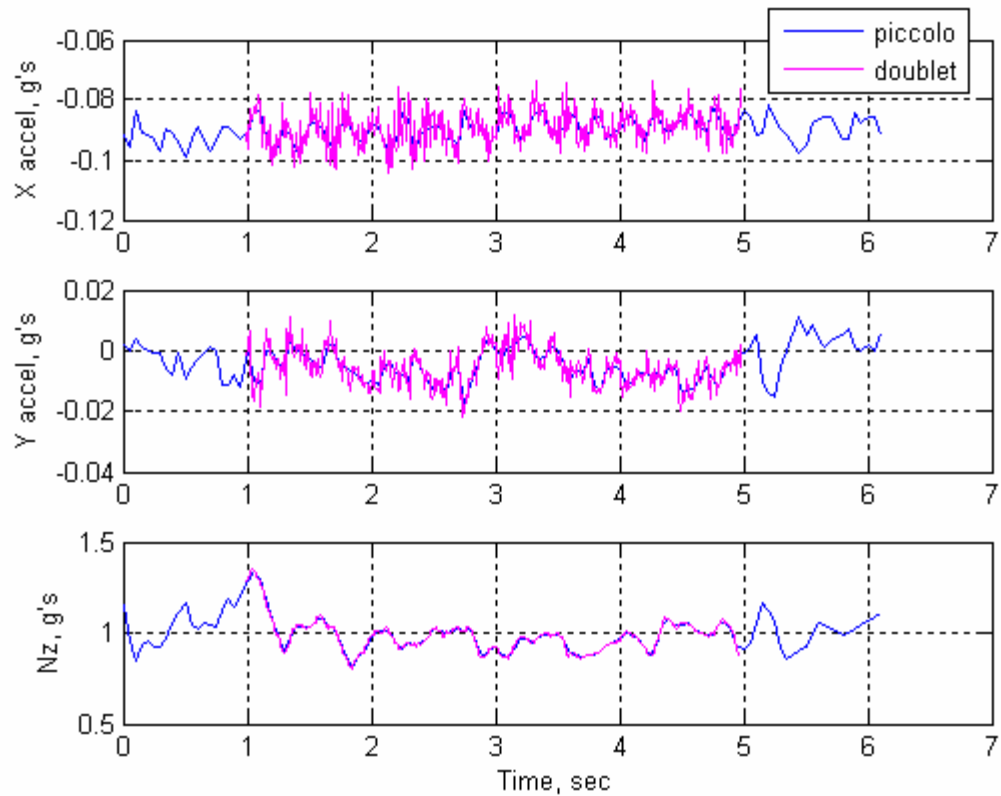
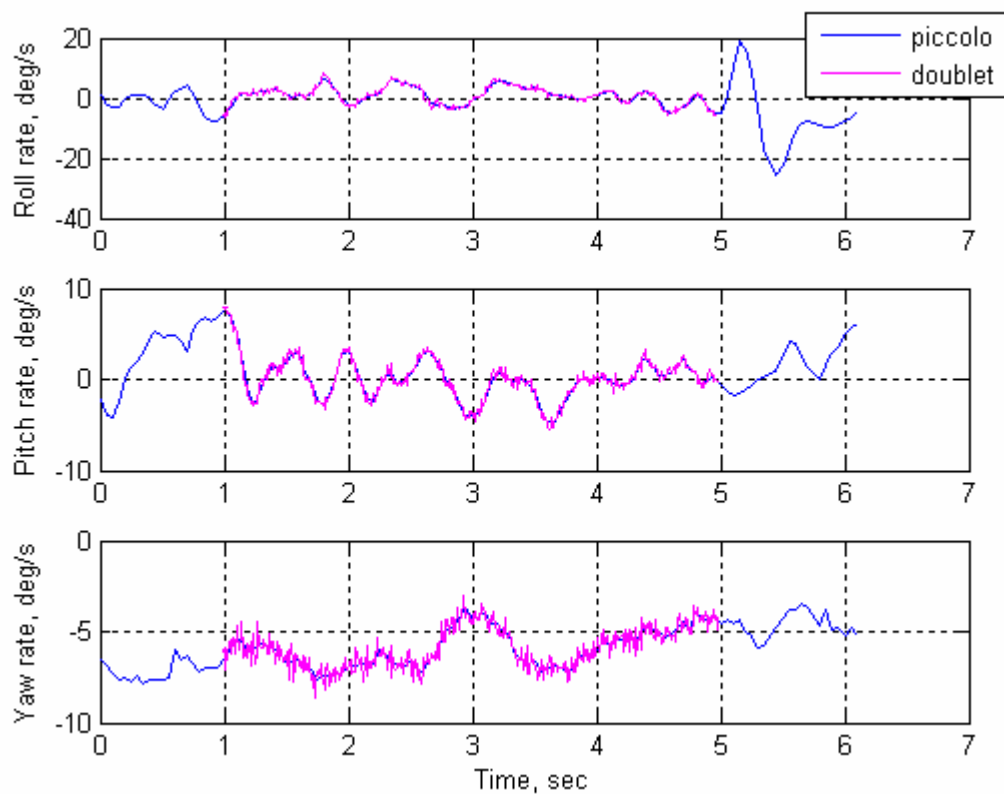


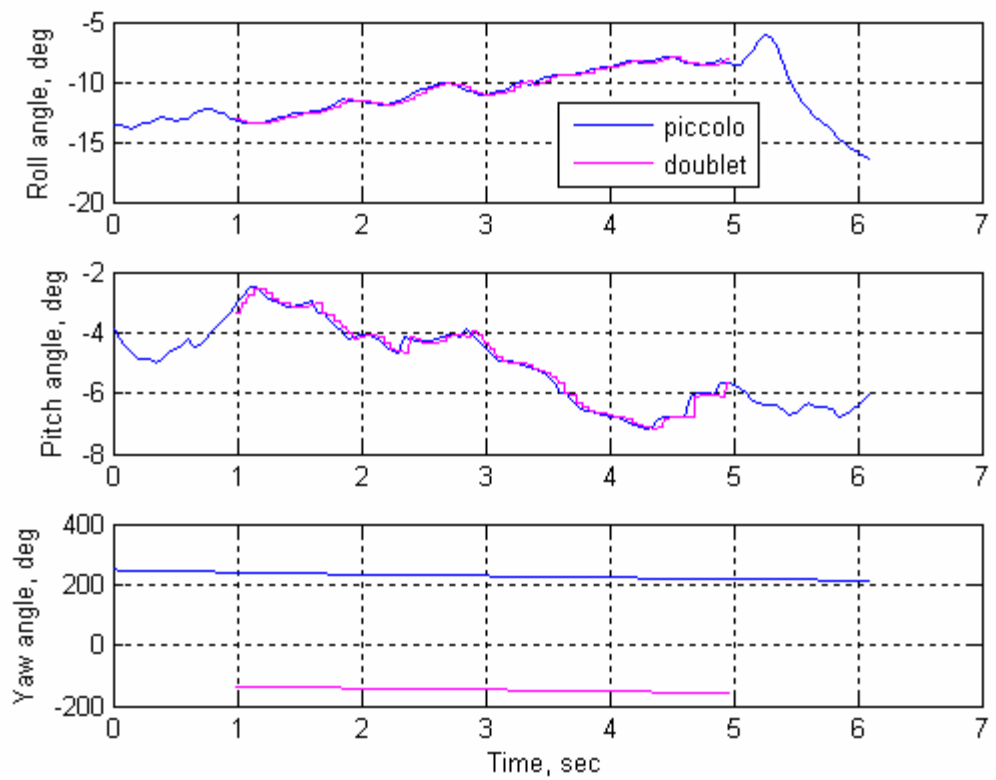
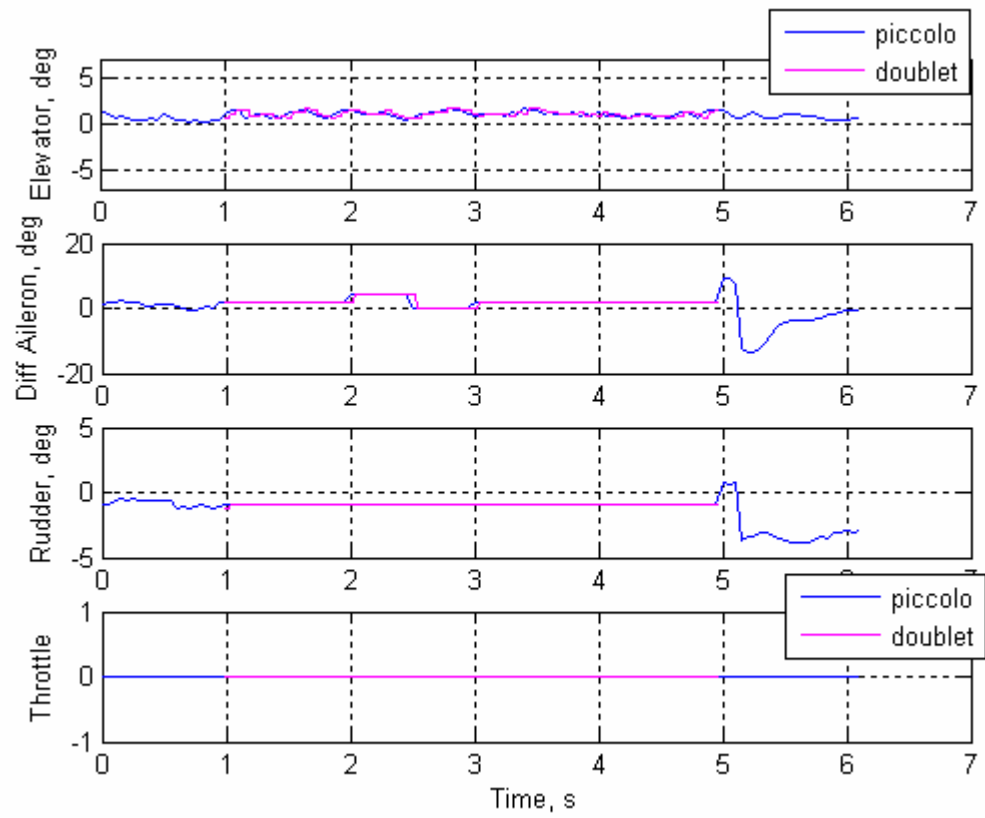
1.6.1 Aileron Doublet

This doublet does not include MFDRS data. Note that the surface commands are not lined up when the rates are aligned in time.



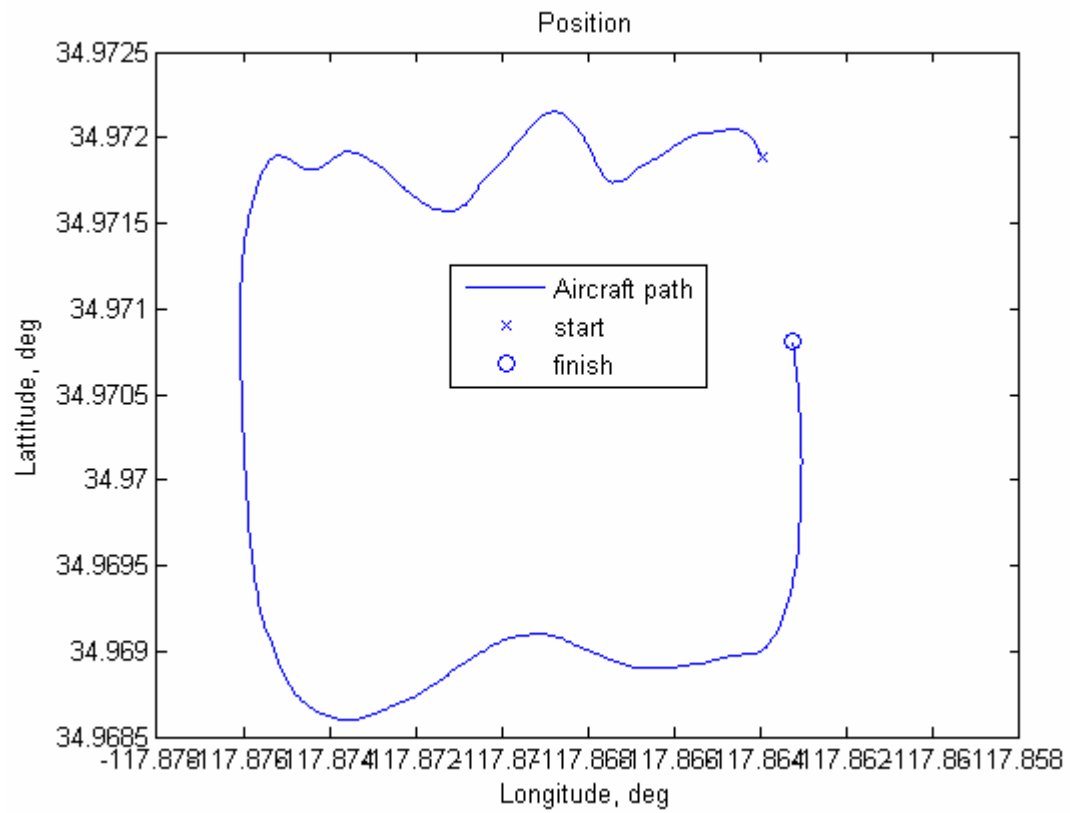


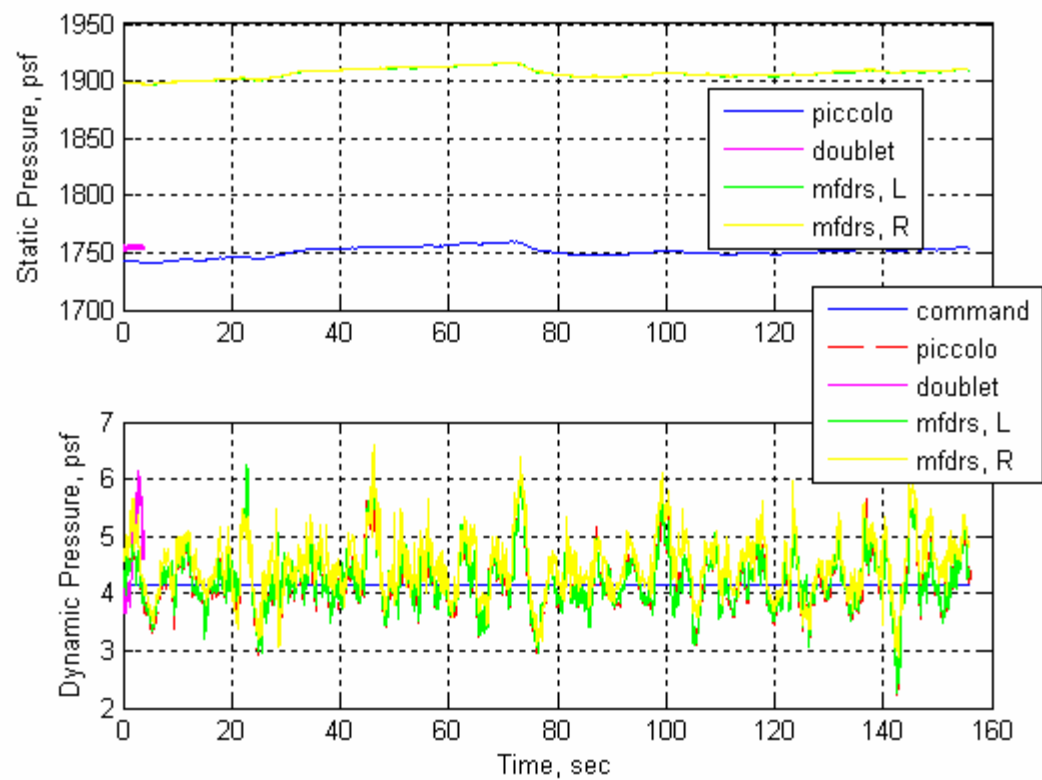
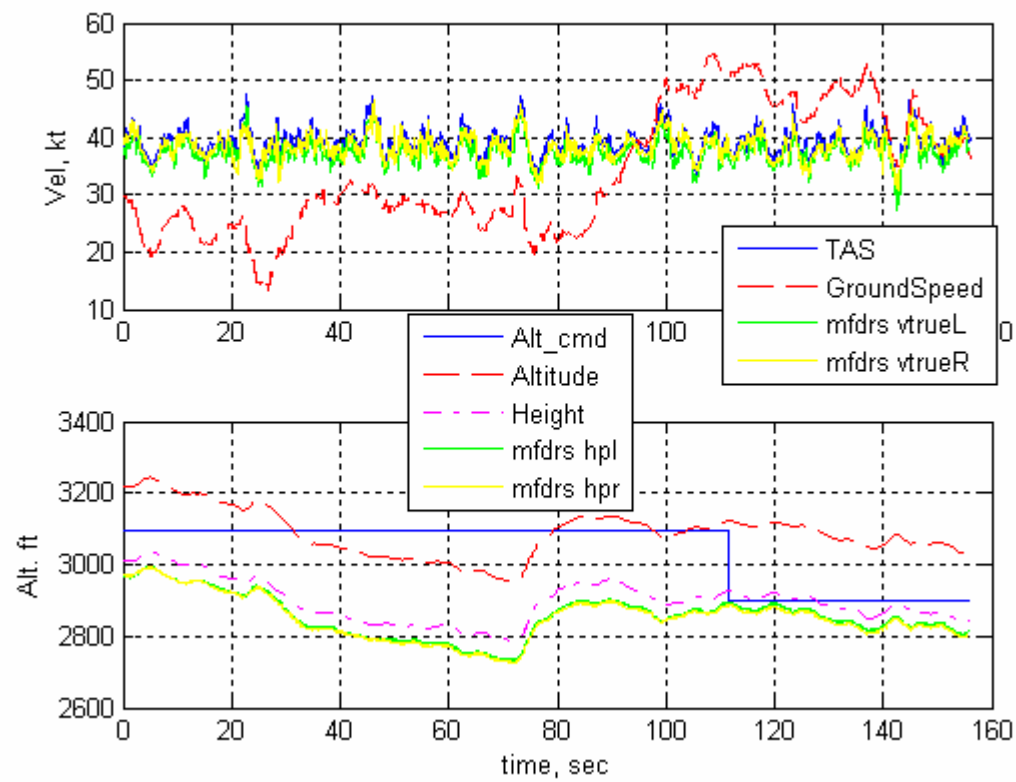


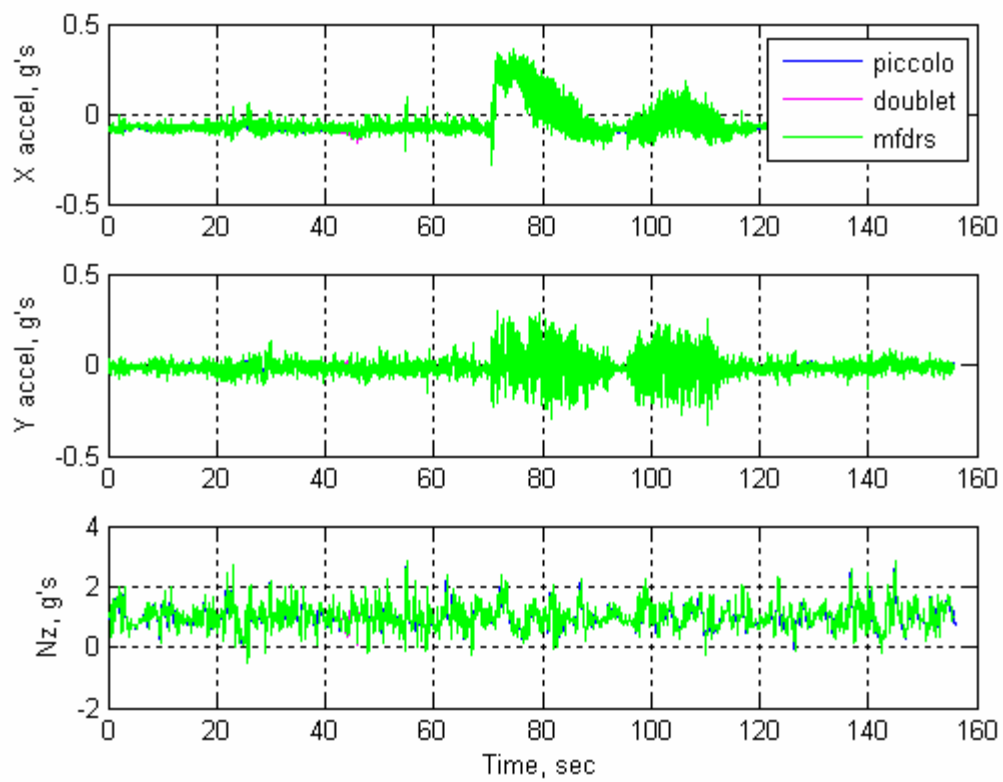
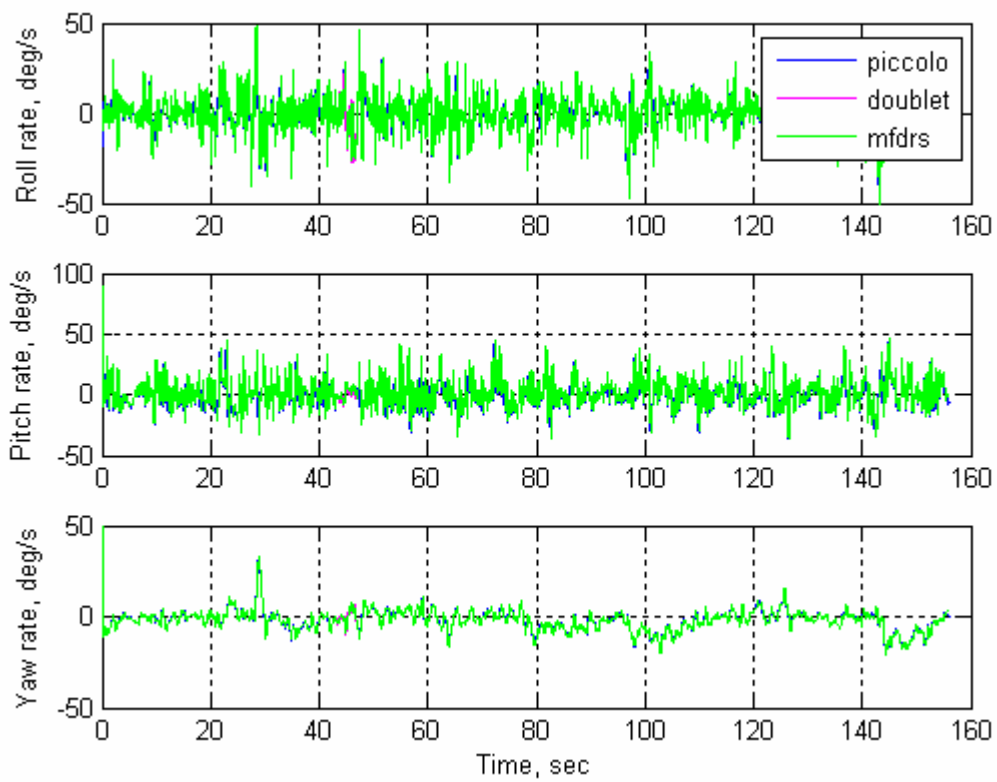


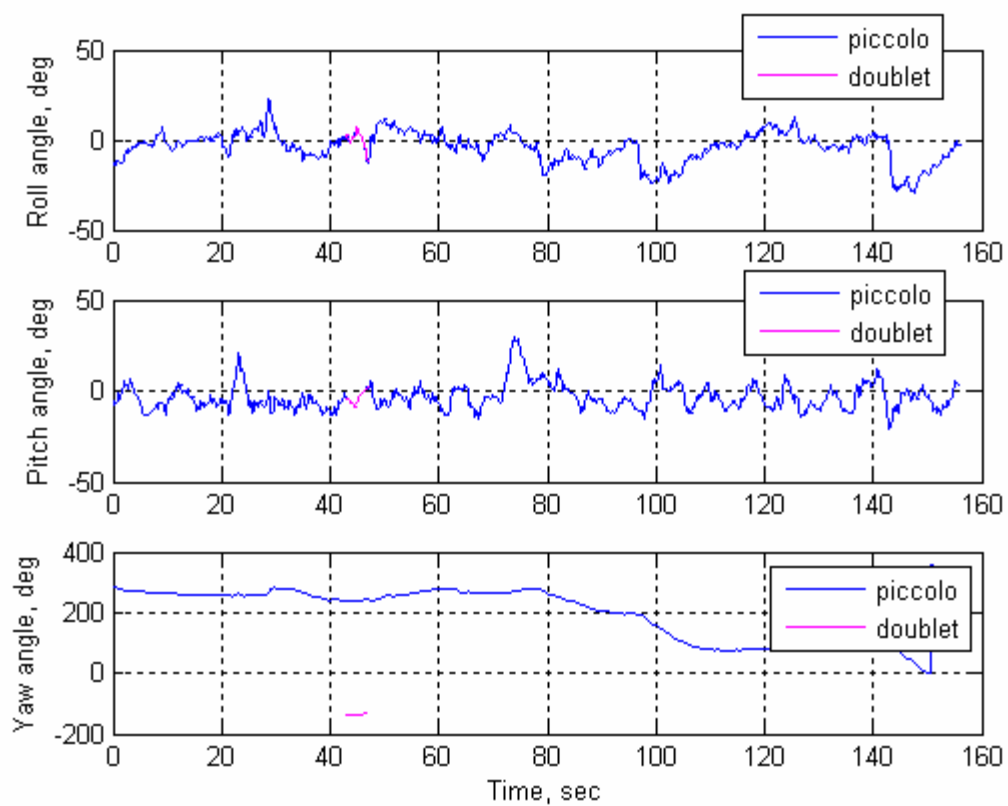
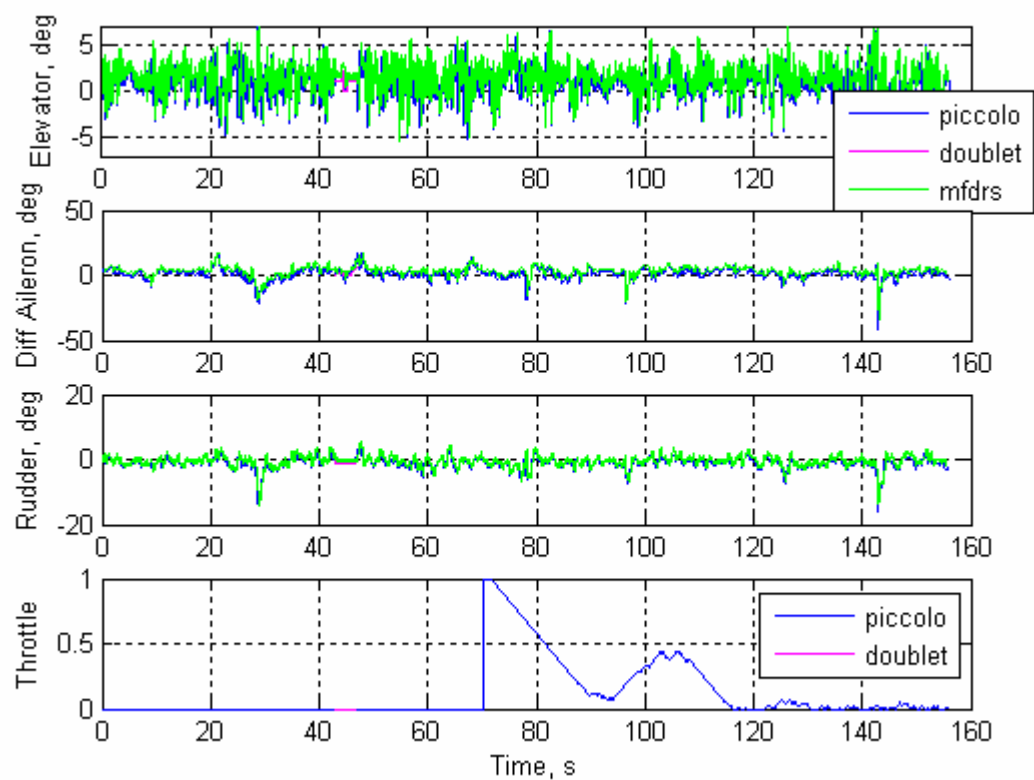
This data was taken from MFDRS RECORD02 from flight 3.

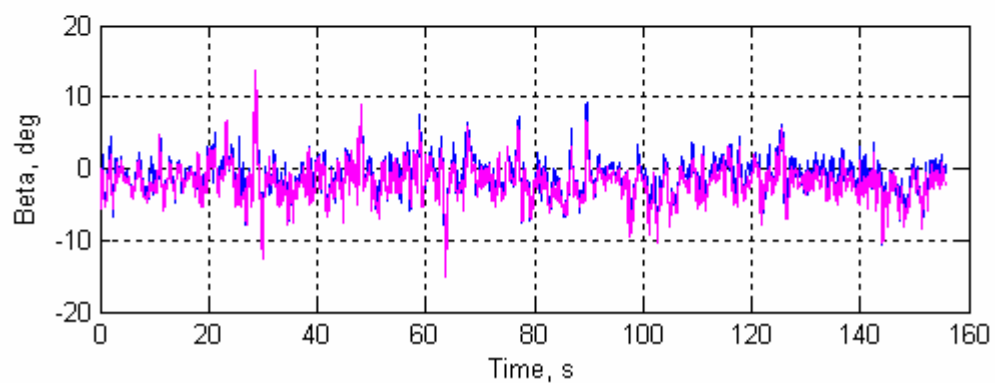
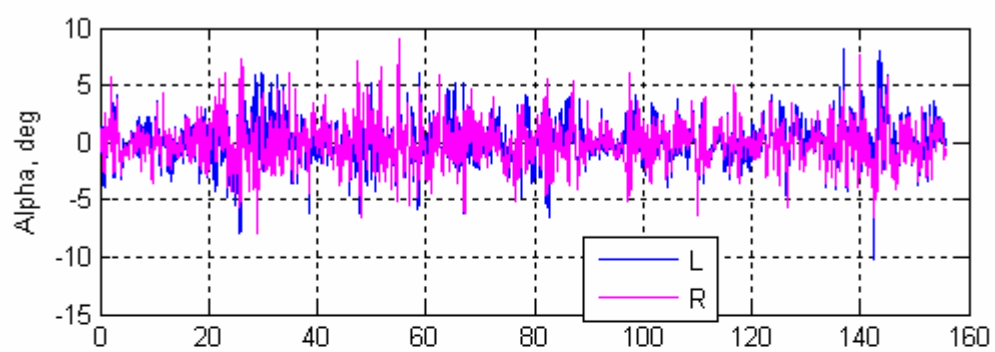
Position





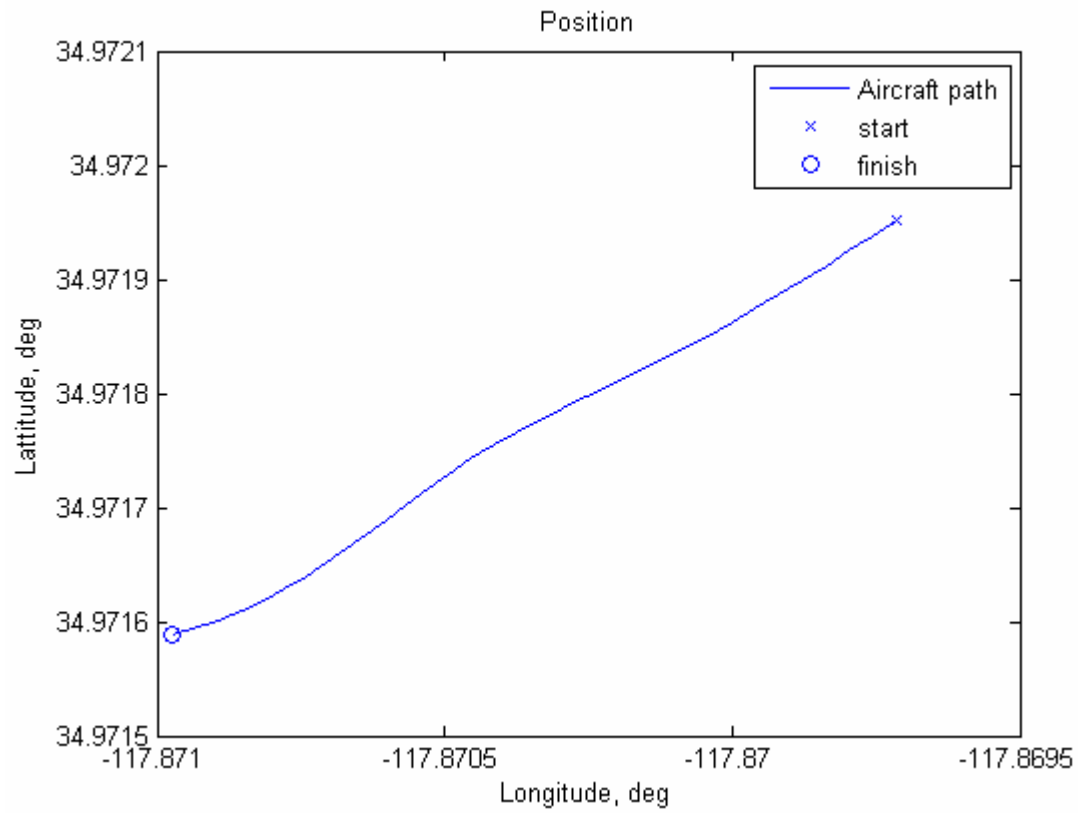


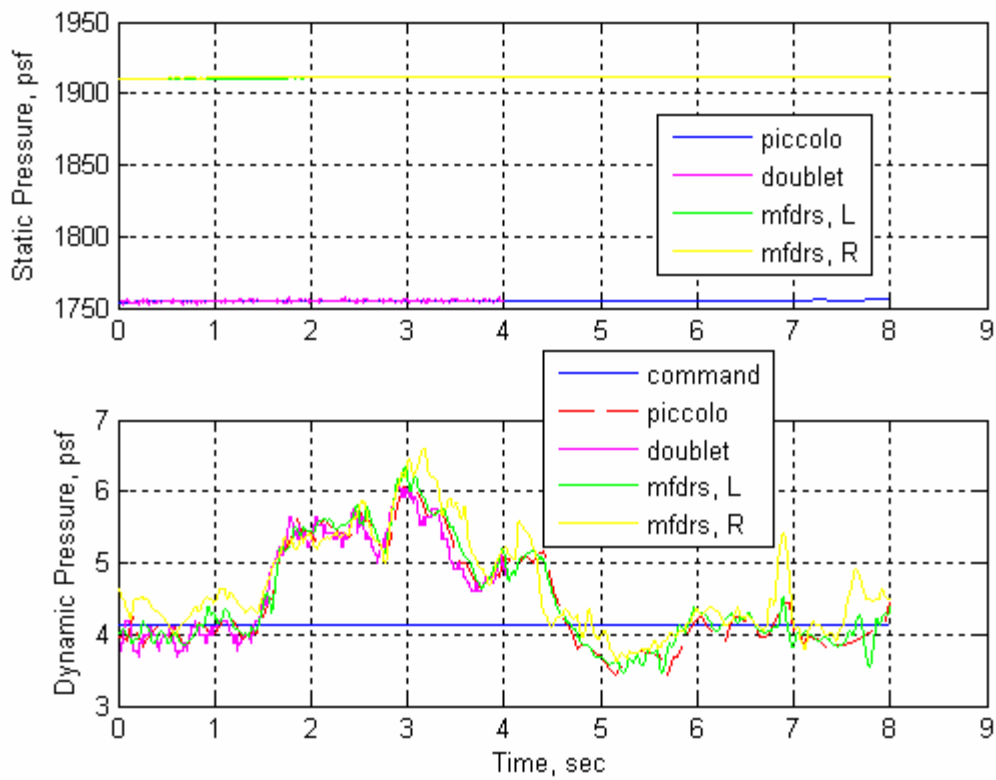
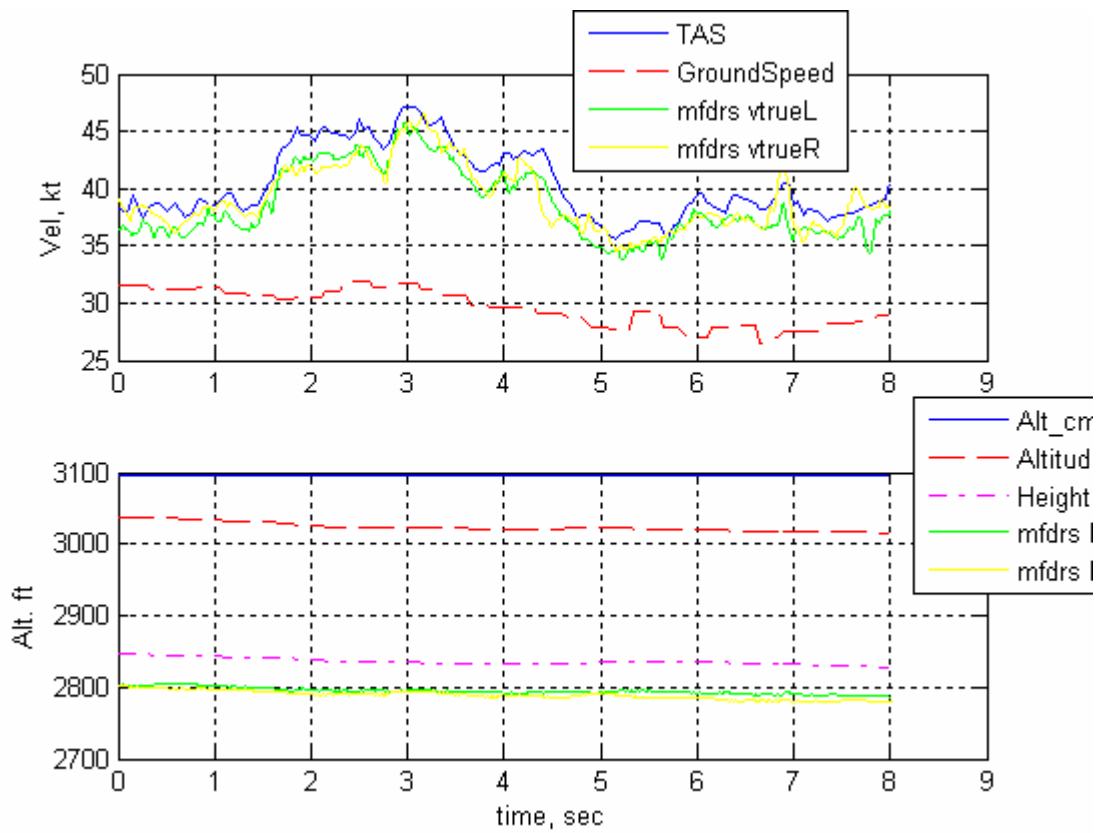


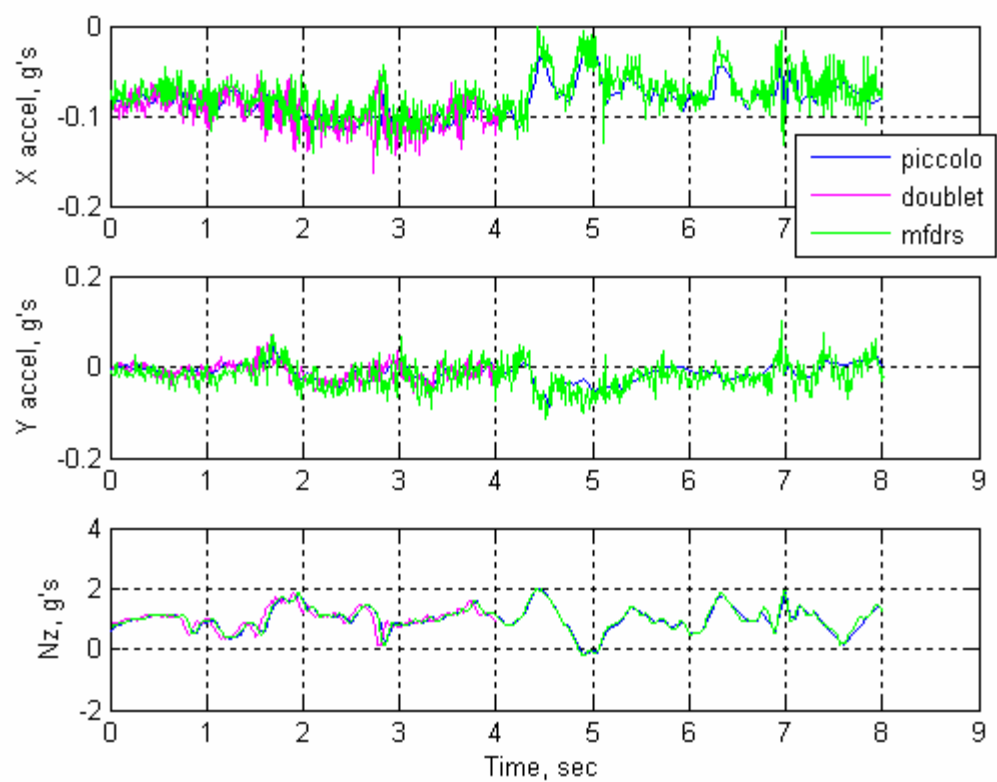
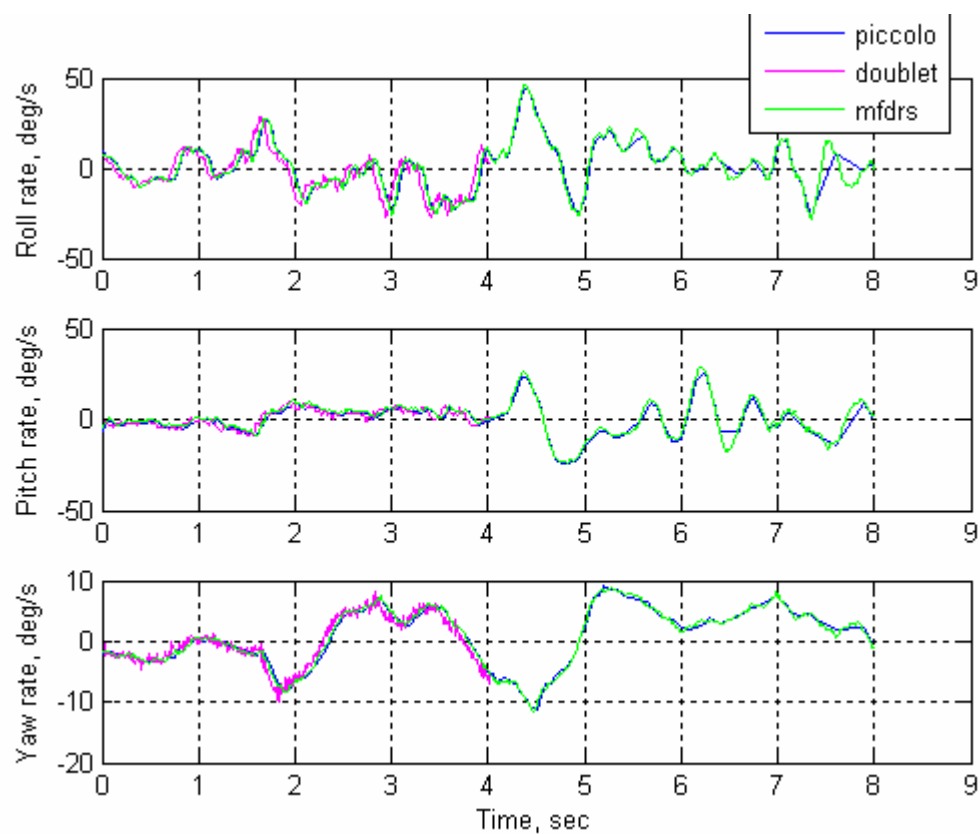


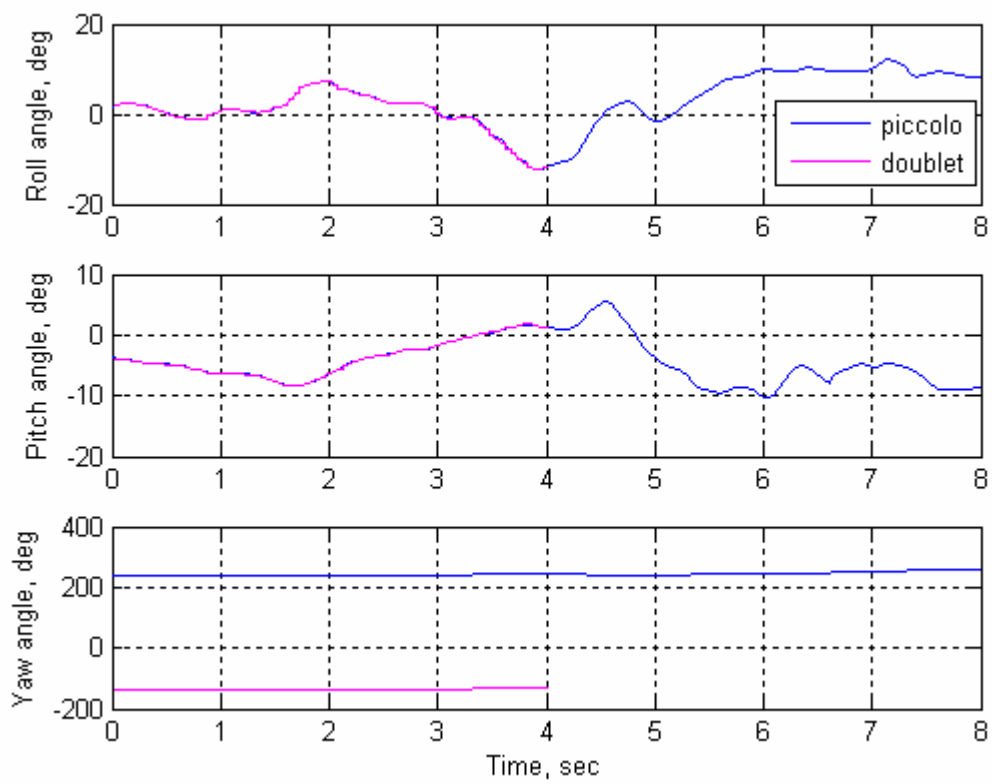
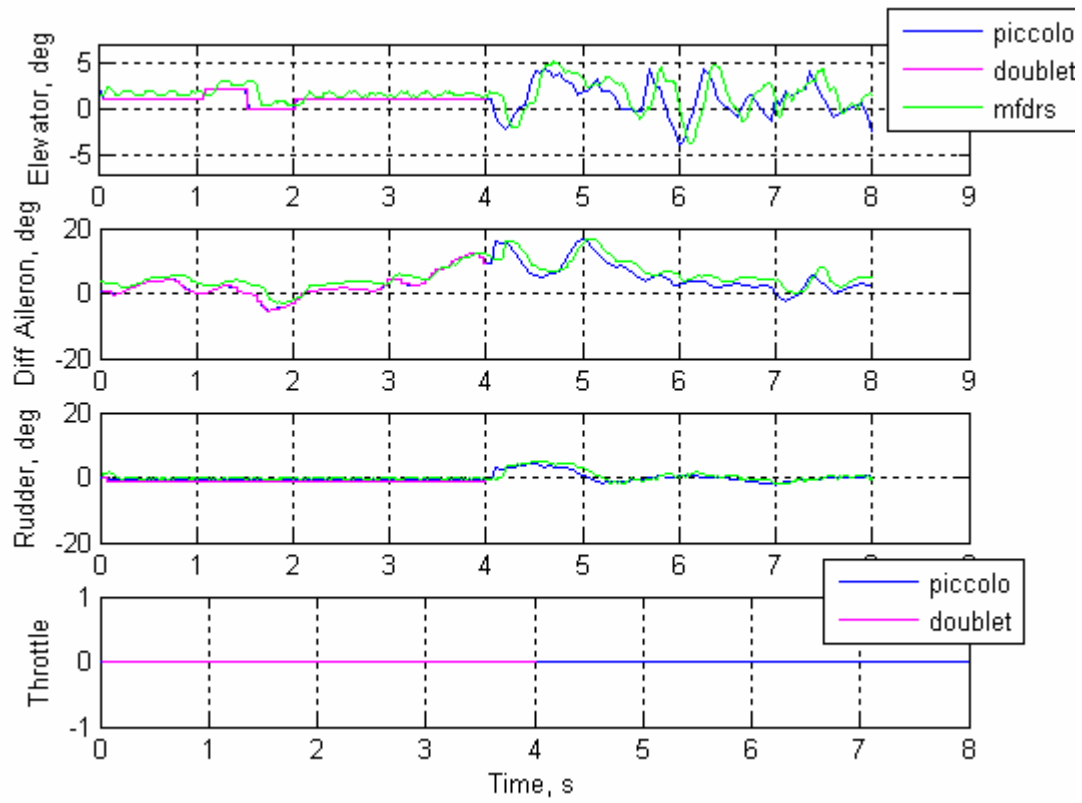
1.6.3 Elevator Doublet, Short

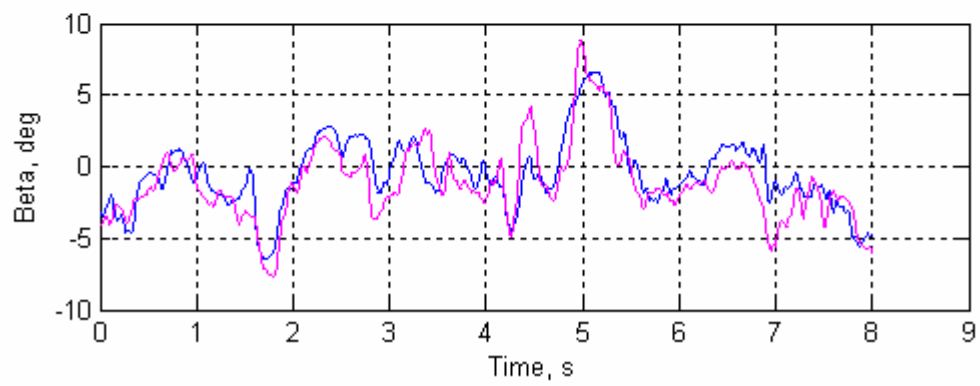
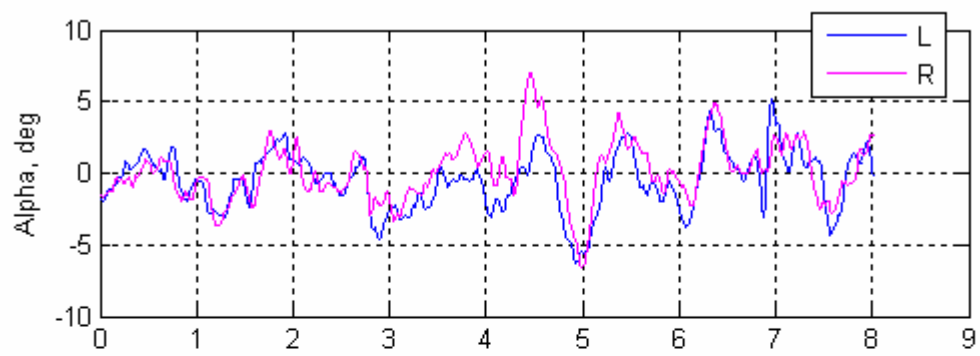
Data came from MFDRS file RECORD02 and [Doublet_flt03_ele2.mat](#)





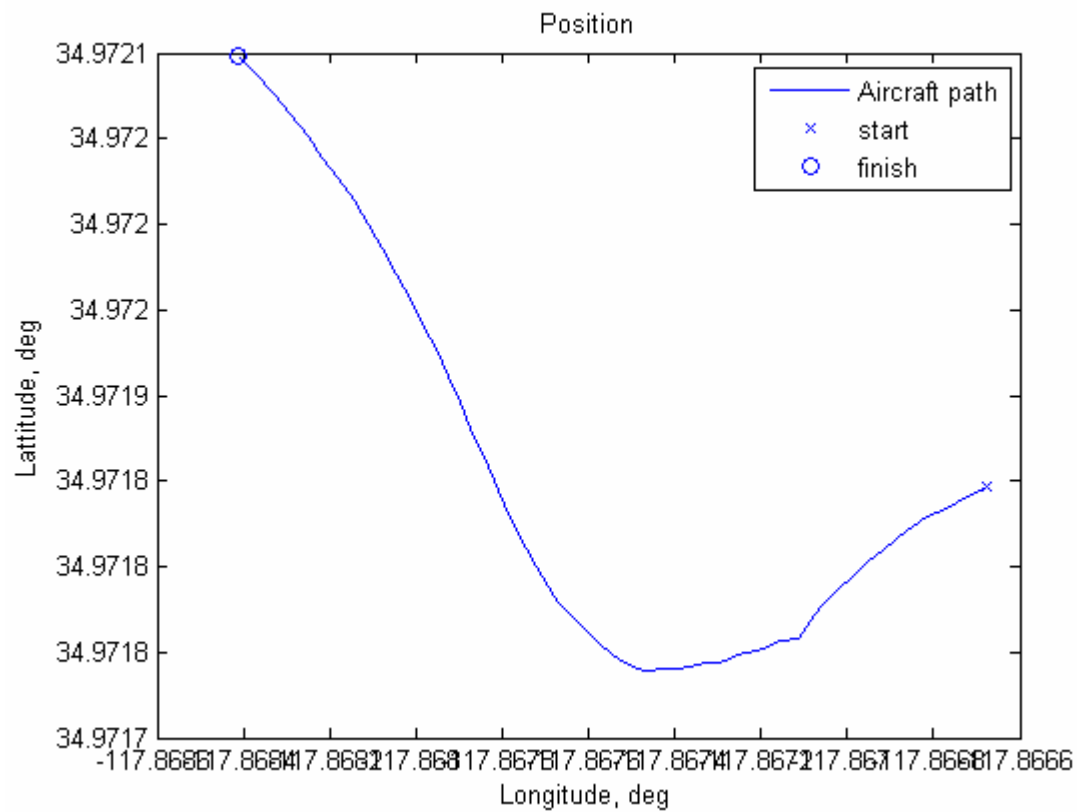


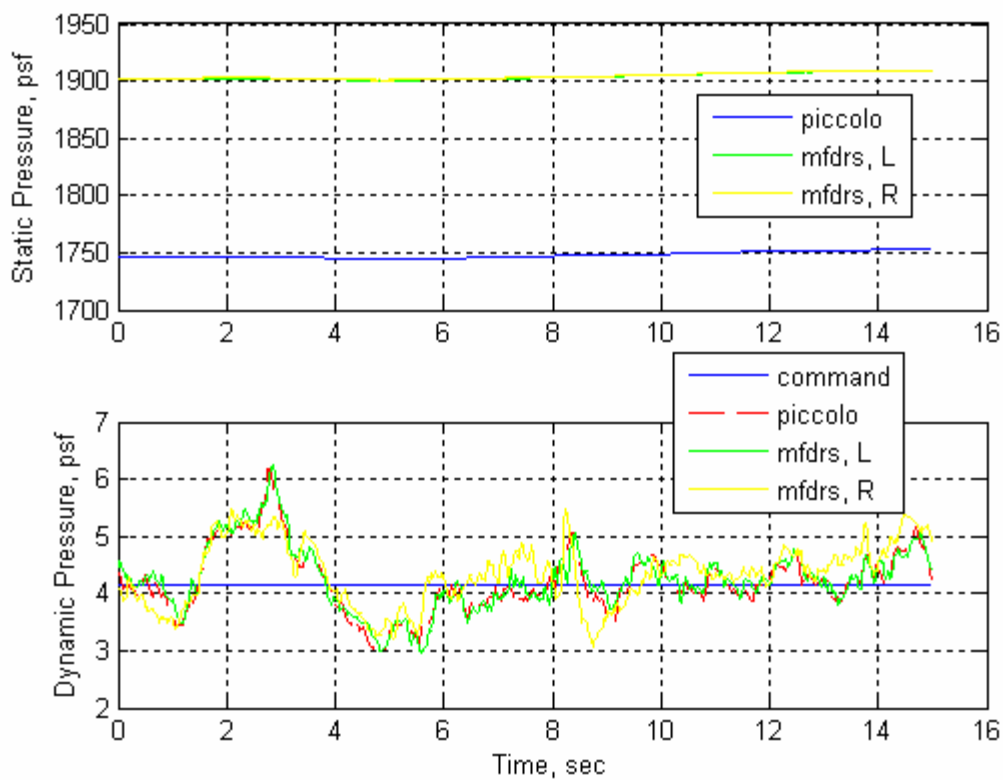
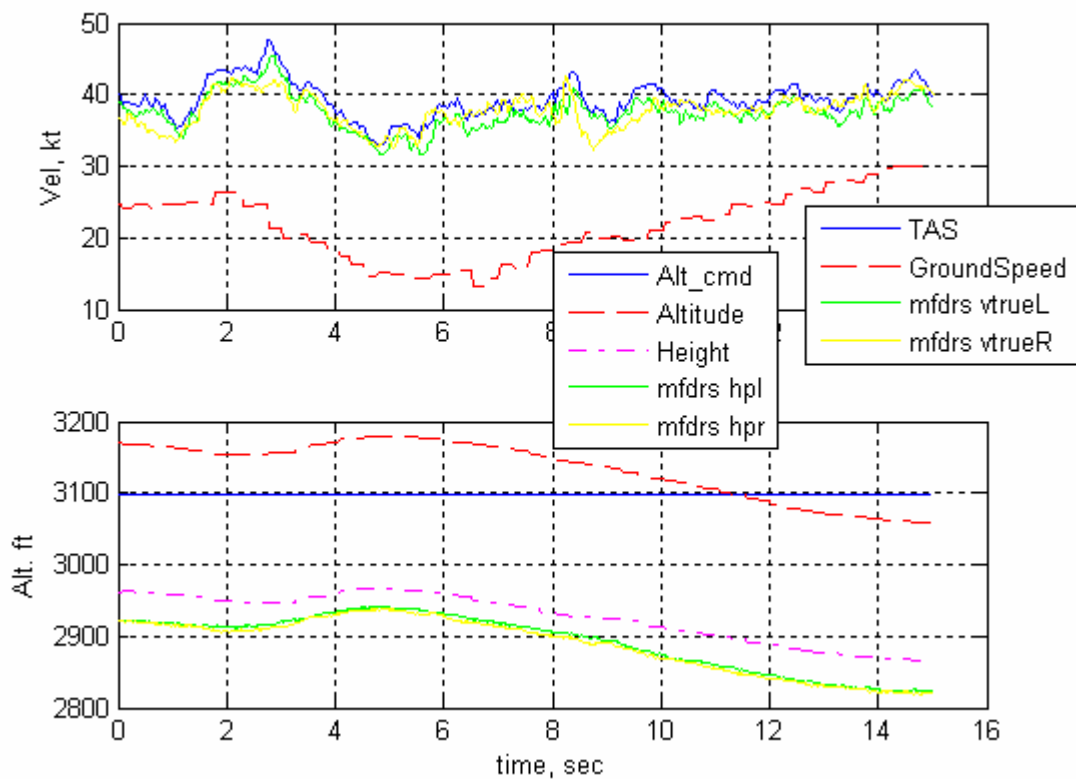


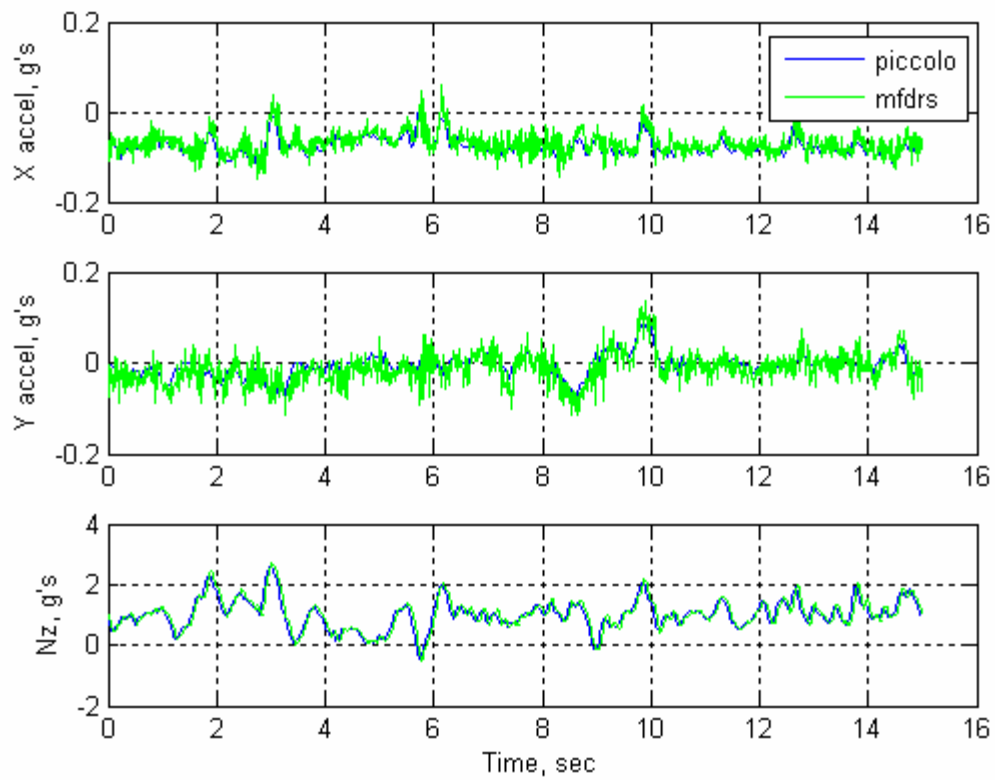
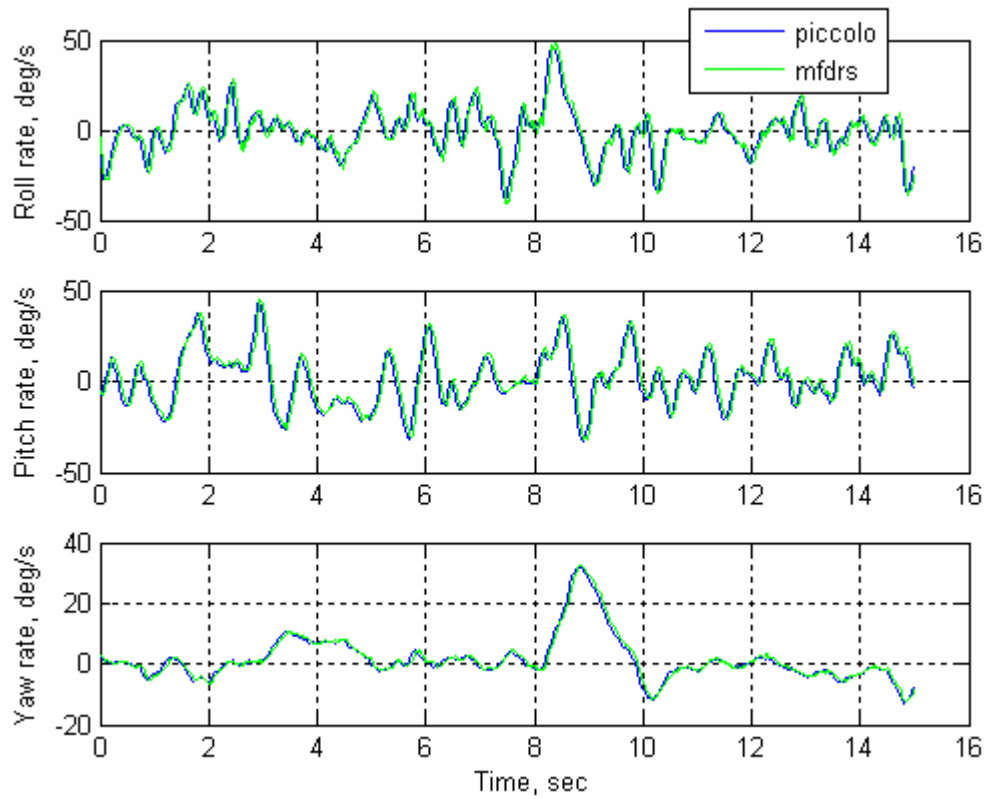


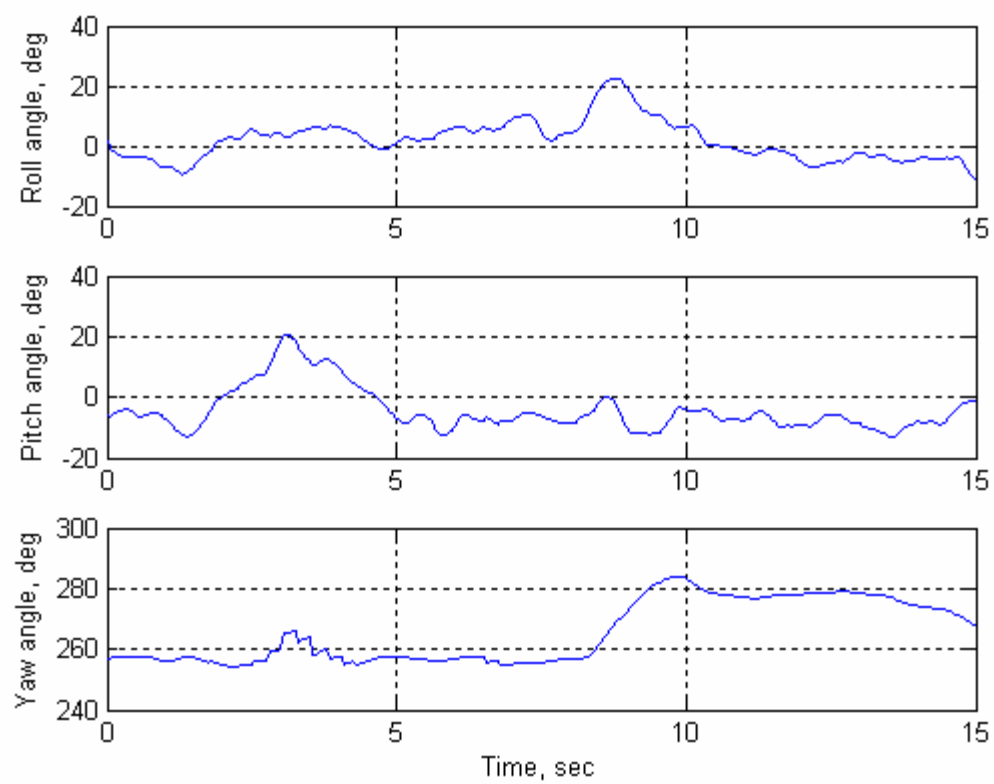
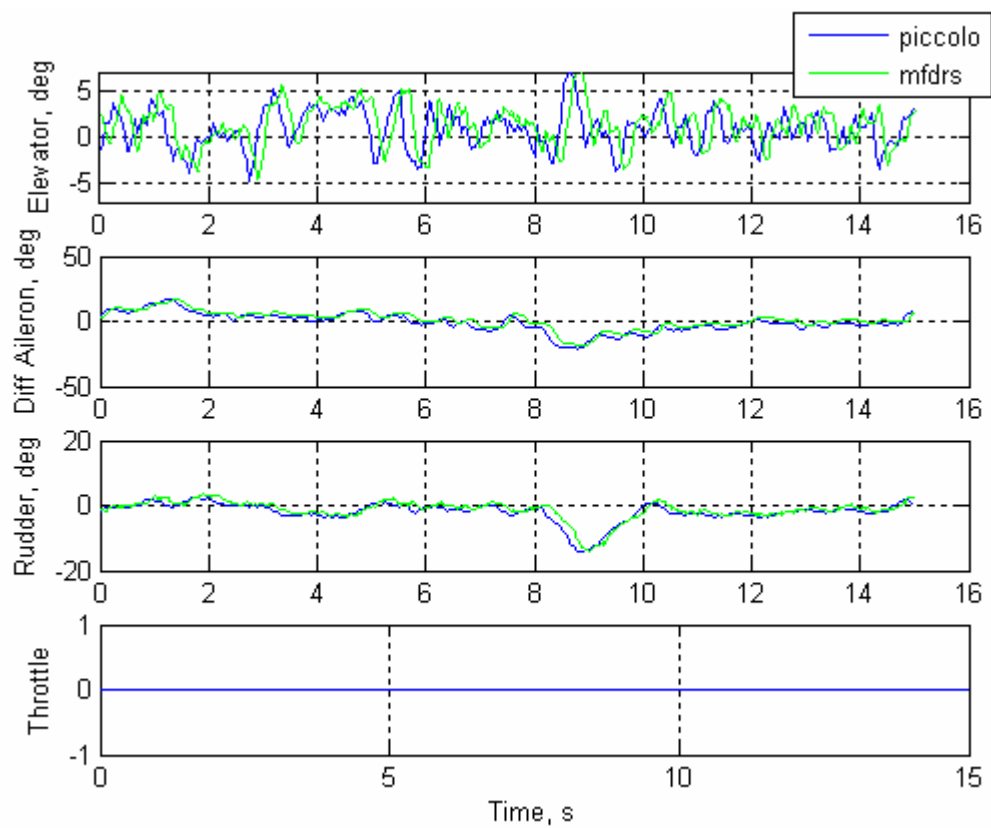
1.6.4 Turbulence

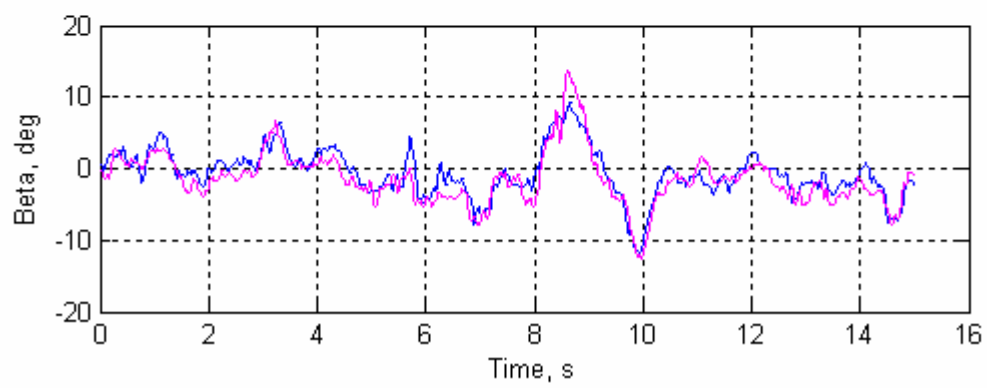
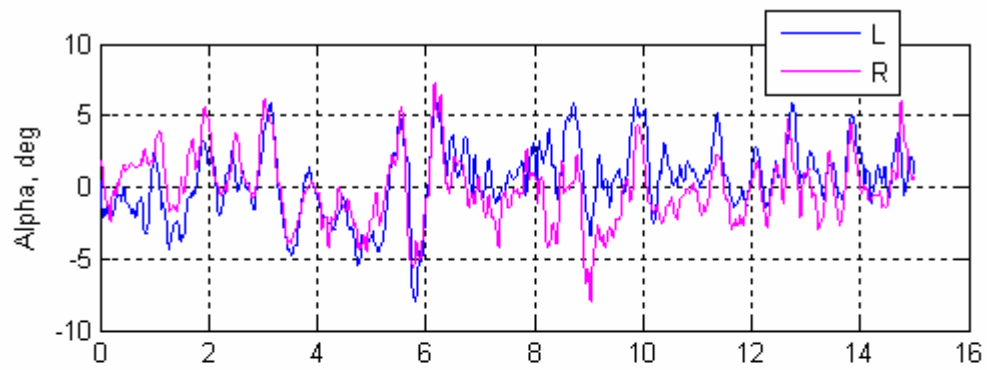
This data was recorded during the setup for elevator doublet 2 of flight 3. The data is 15 seconds of 40kt gliding flight through turbulence.





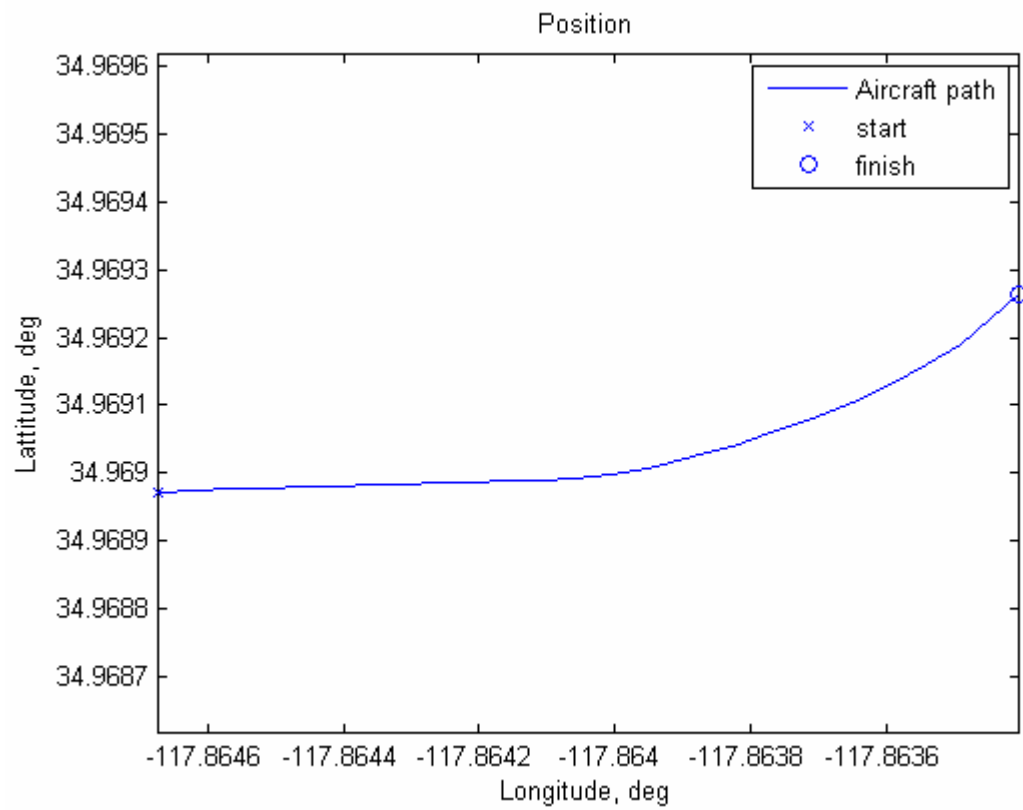


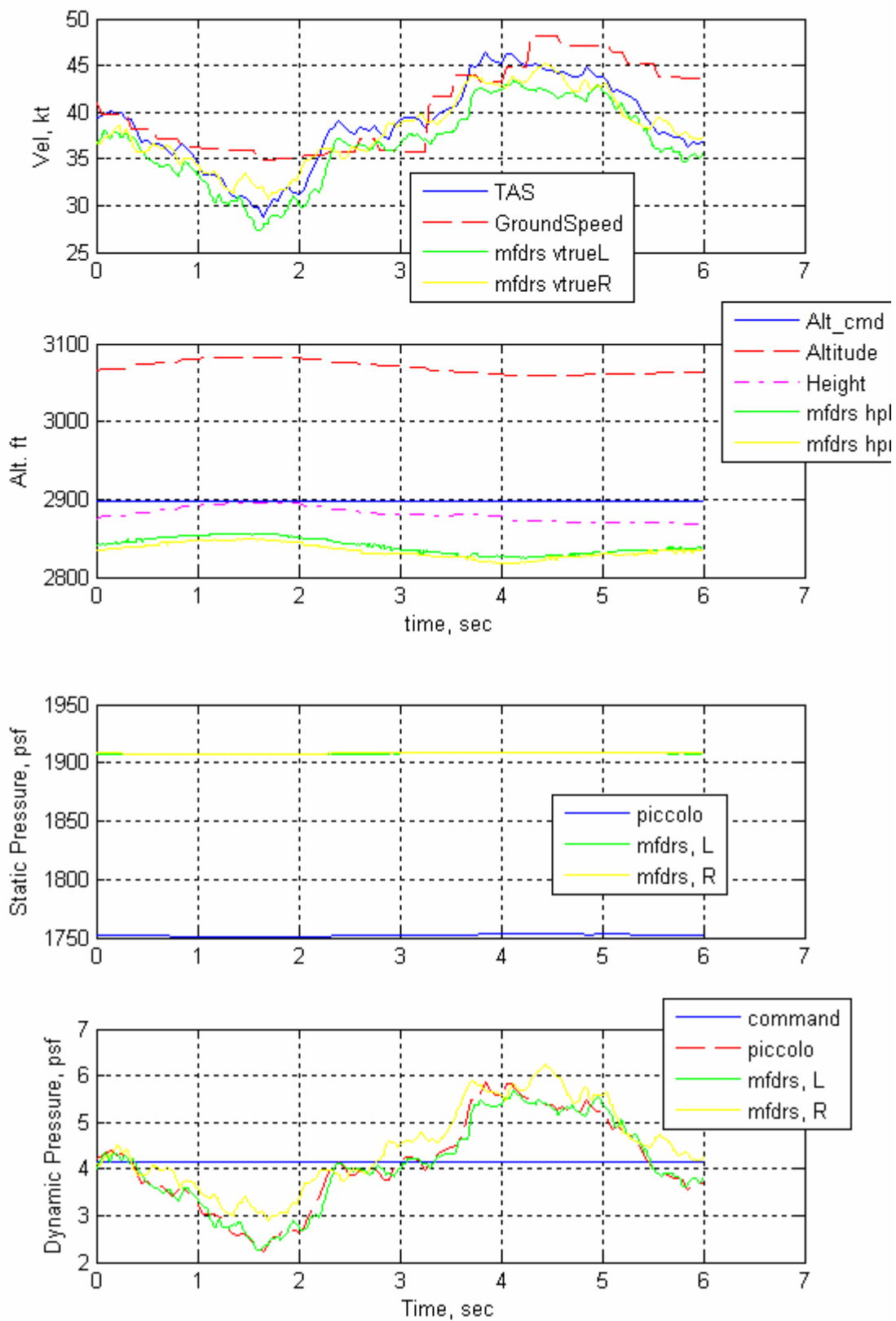


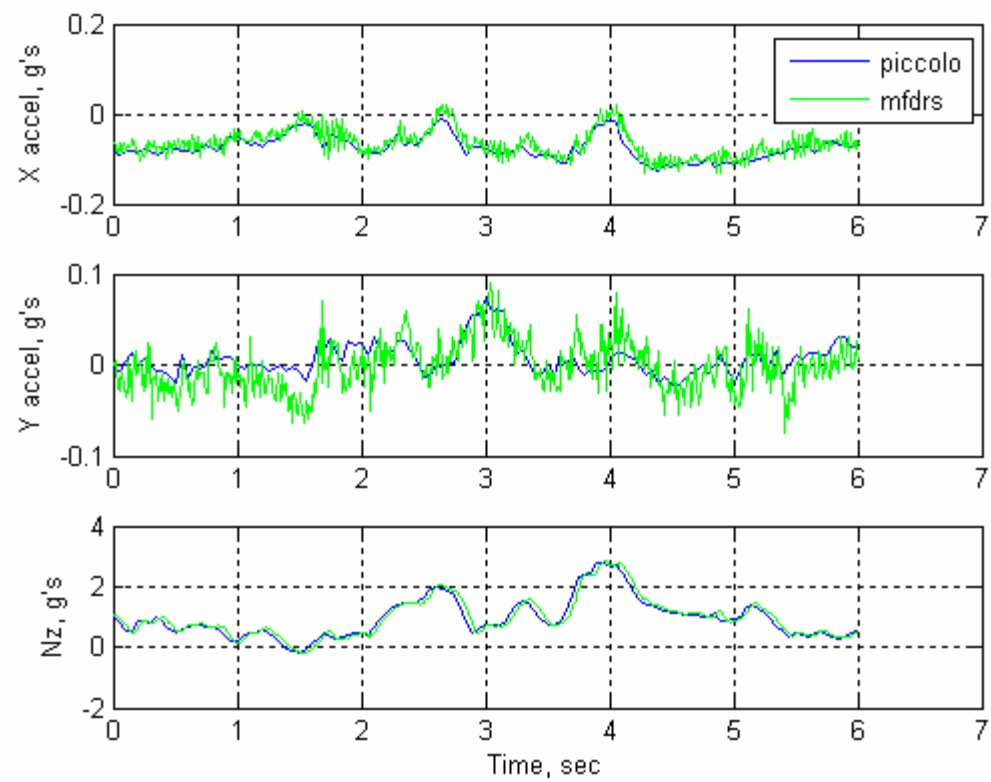
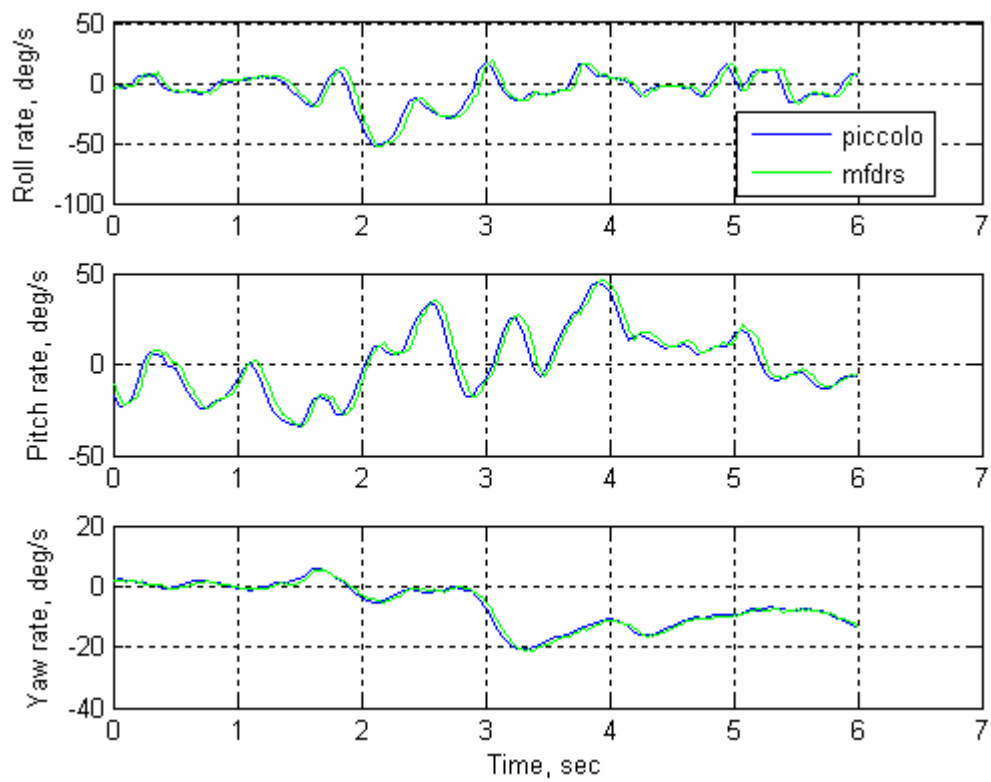


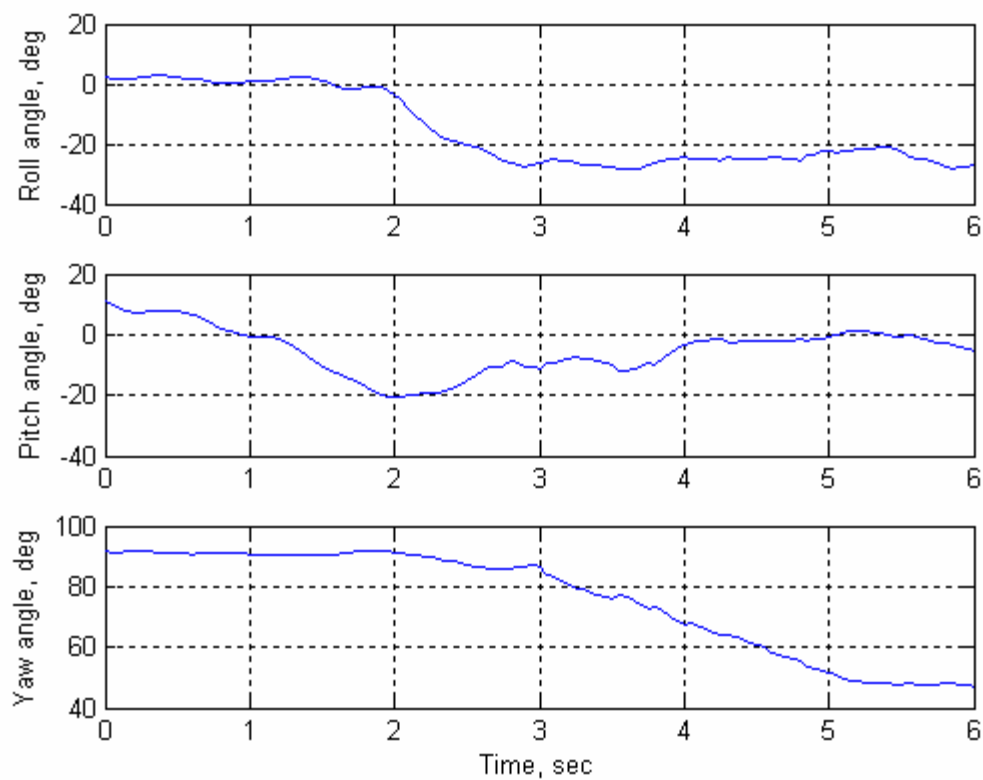
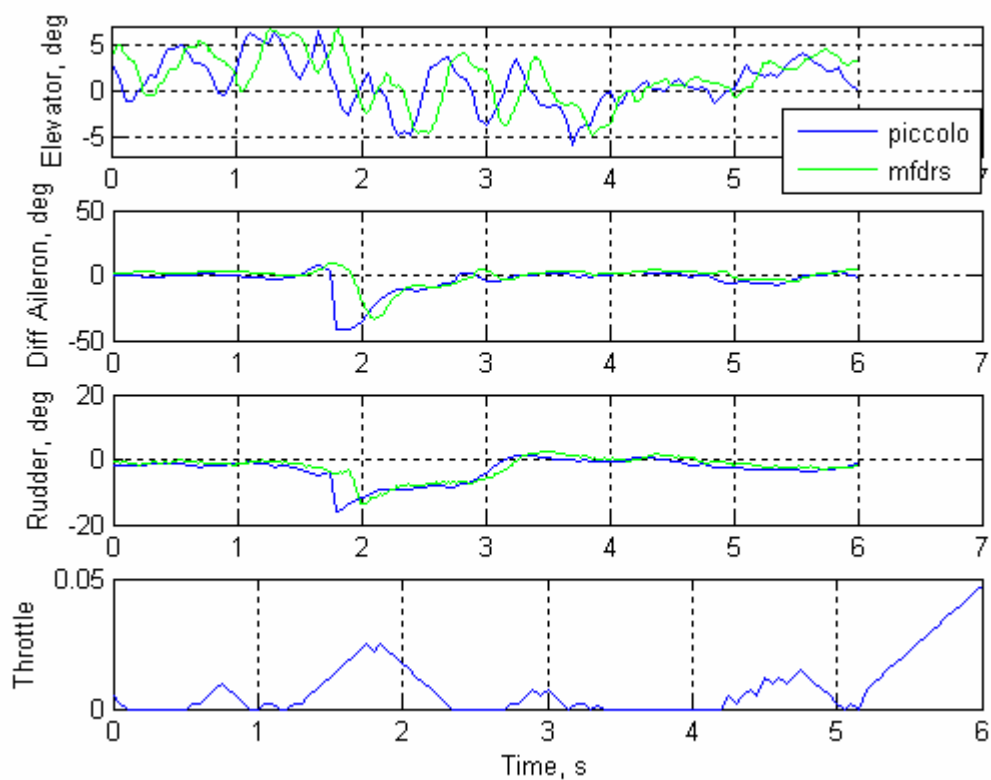
1.6.5 Turn 1

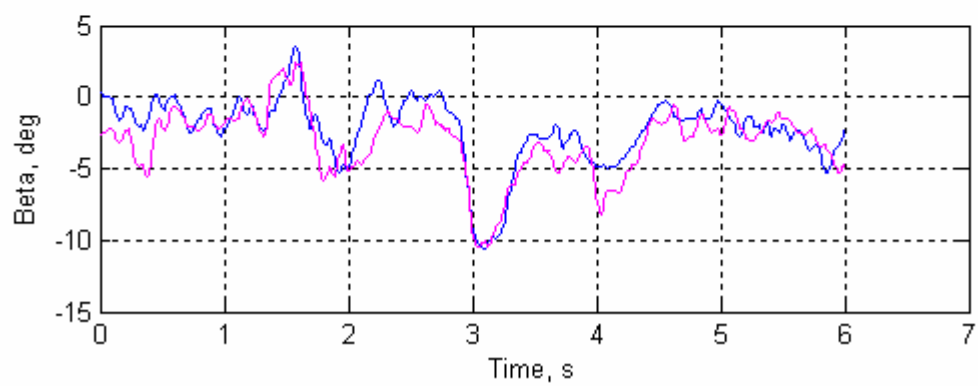
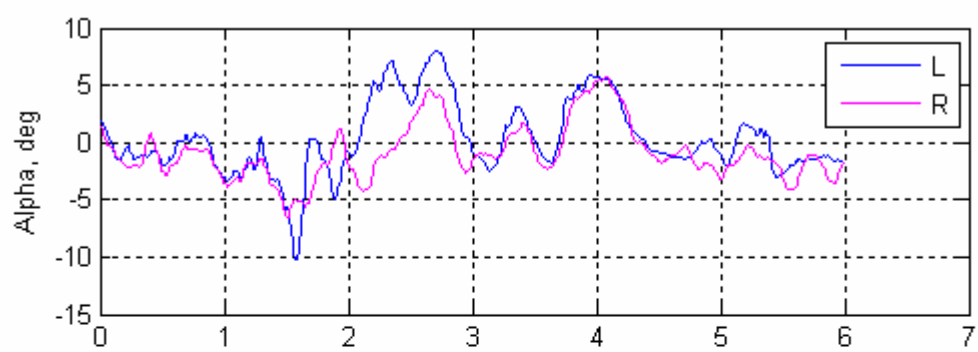
Another bit of data gleaned from MFDRS02. Gliding flight at 40kt with a left turn in strong turbulence.





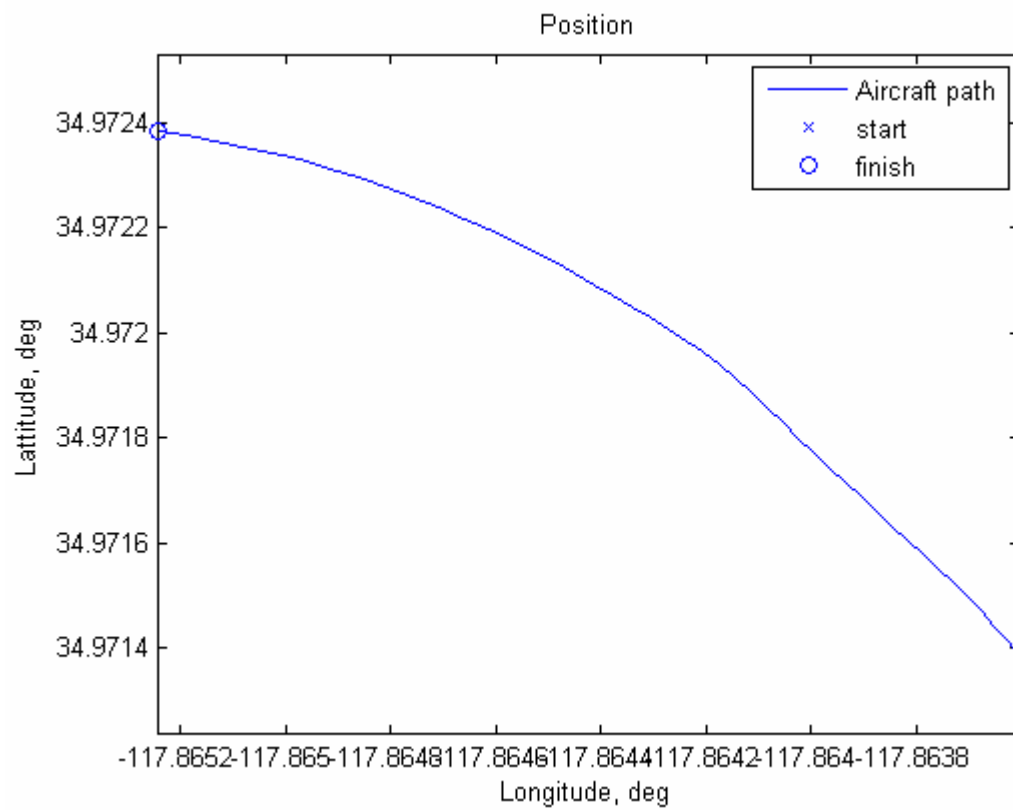


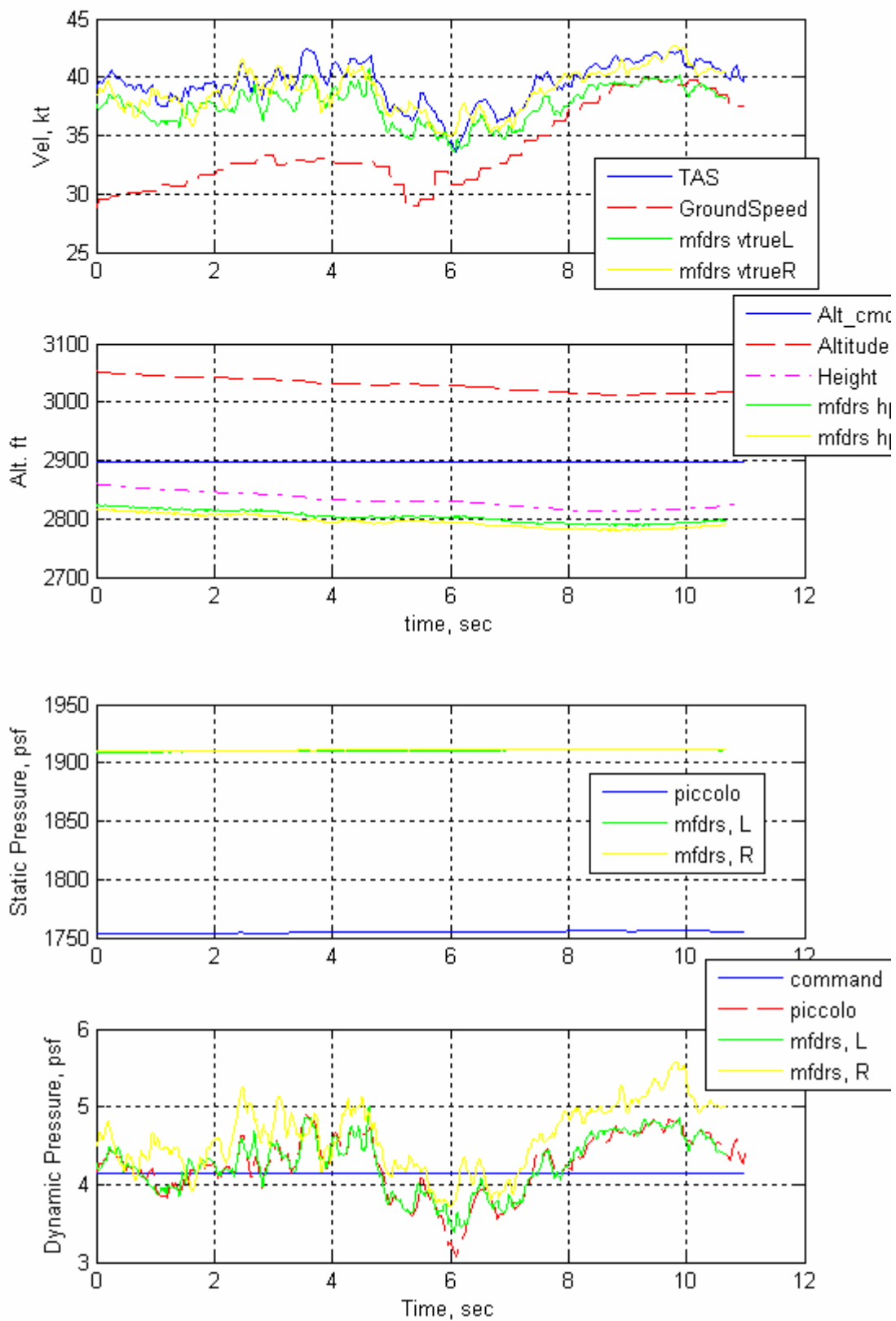


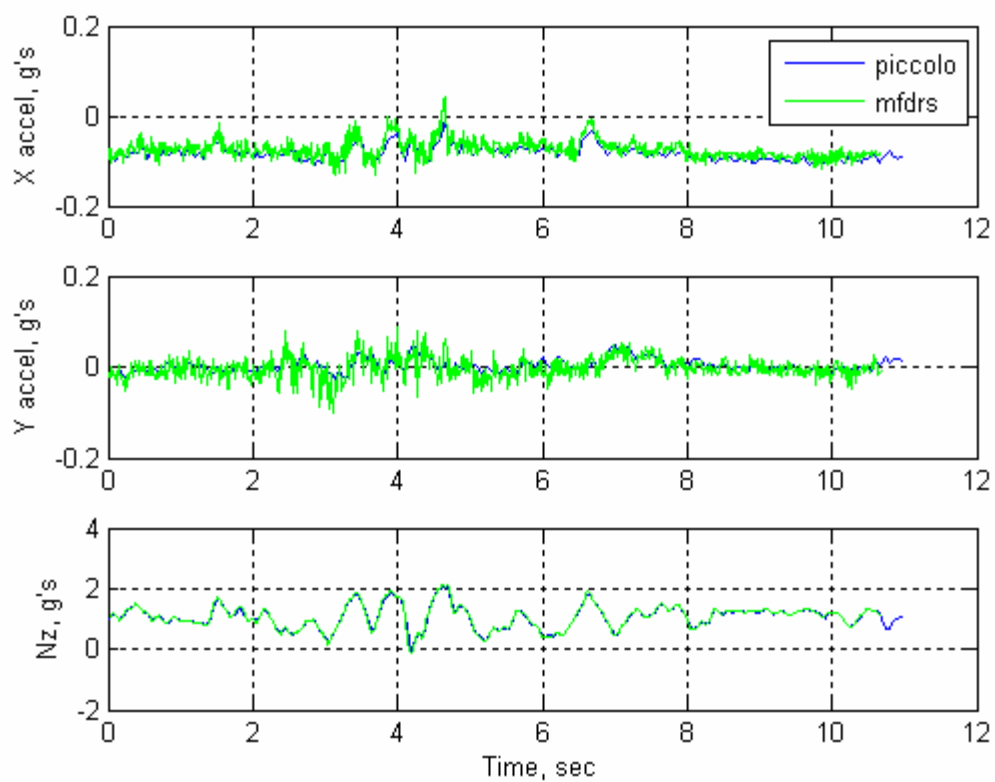
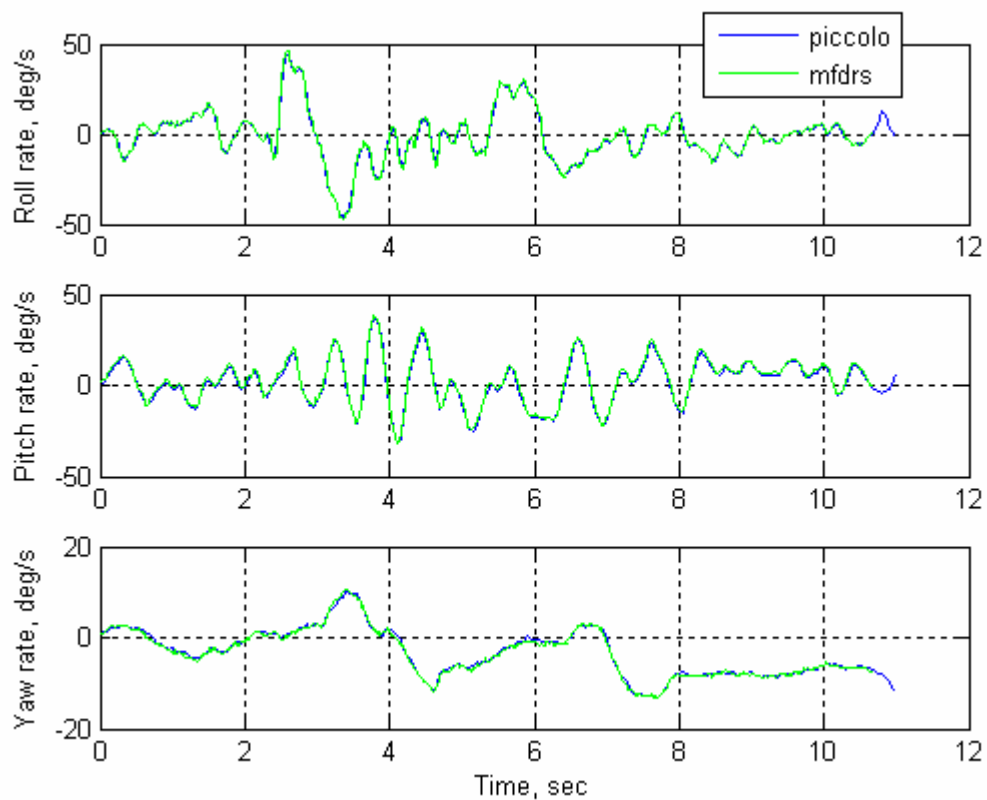


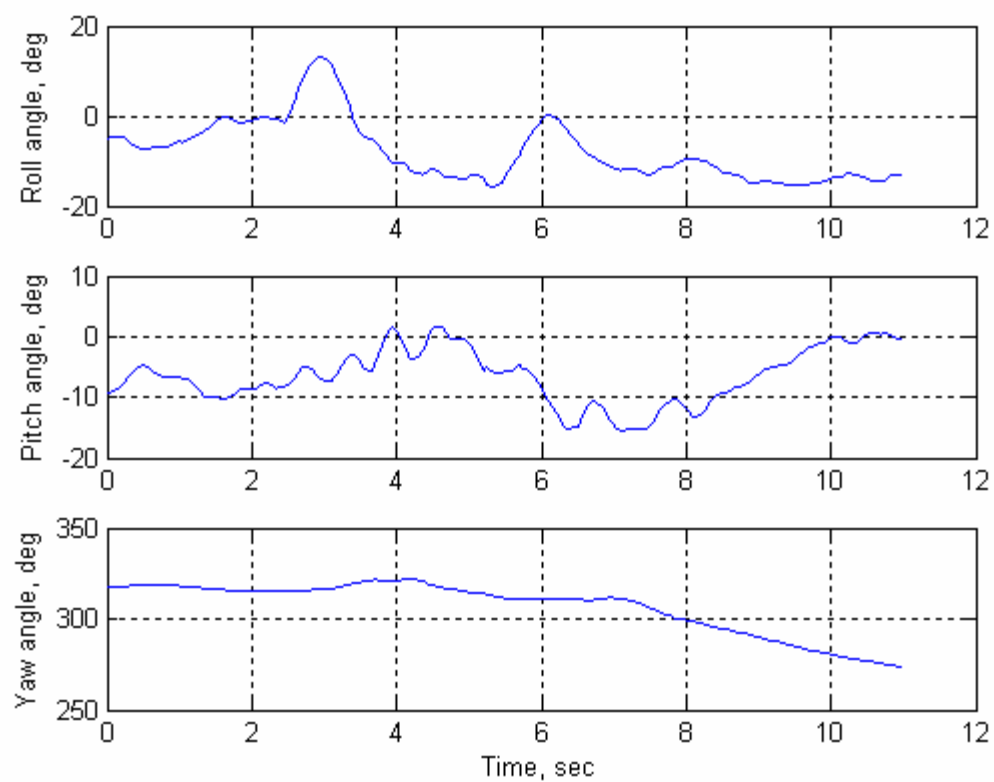
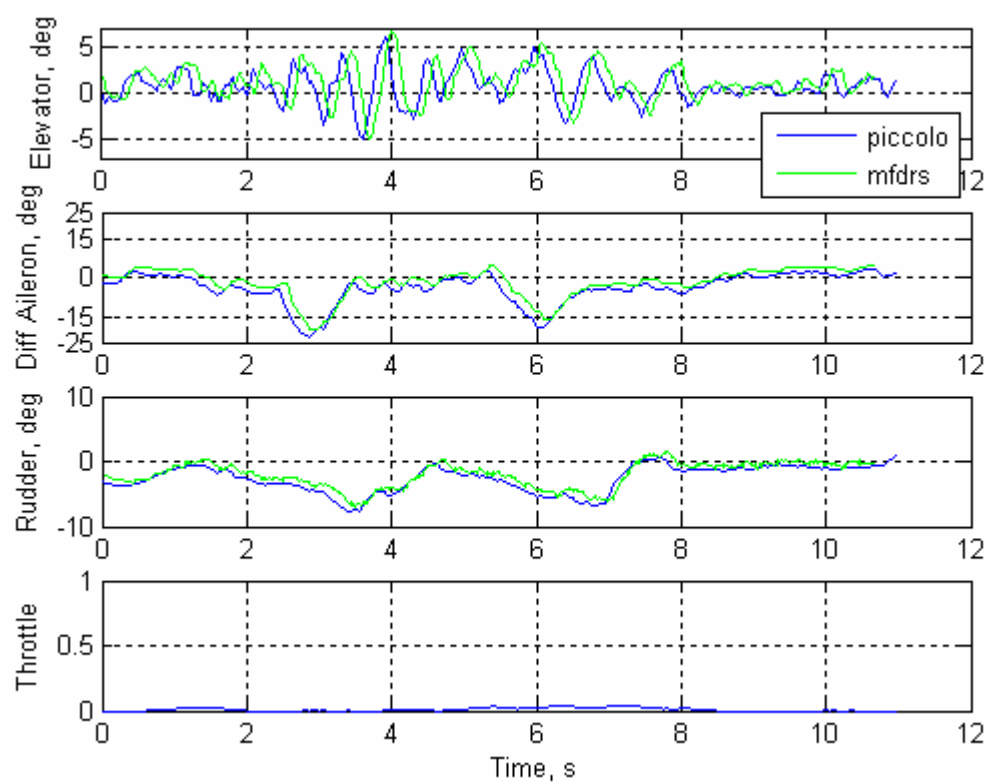
1.6.6 Record 02

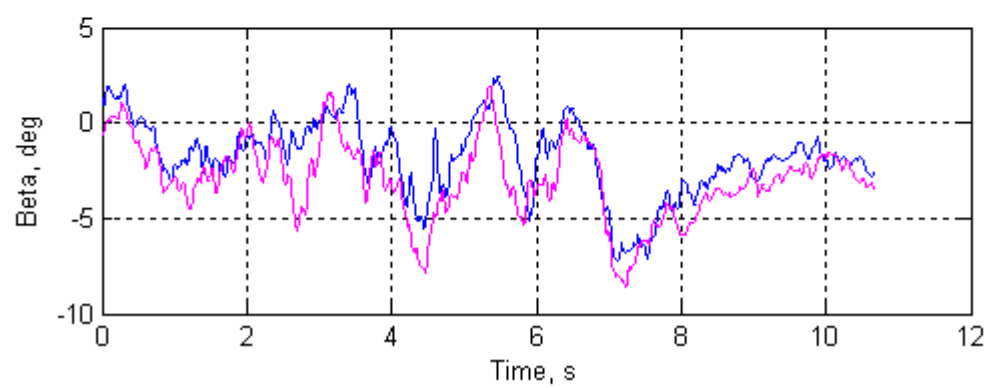
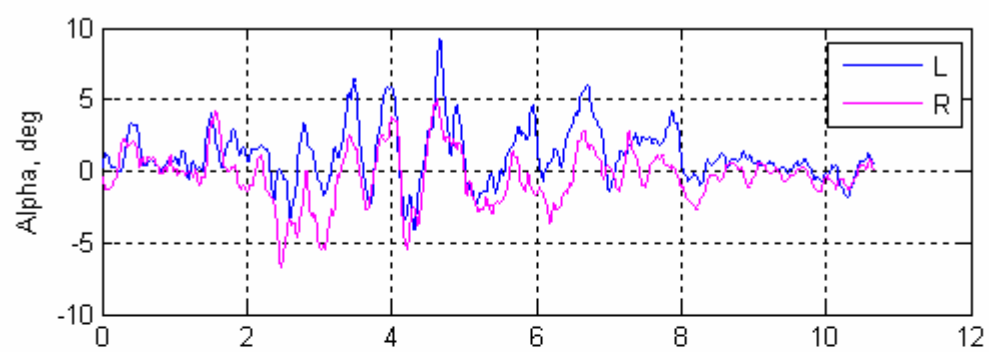
This is the data from MFDRS RECORD02. This seems to be an aborted maneuver.





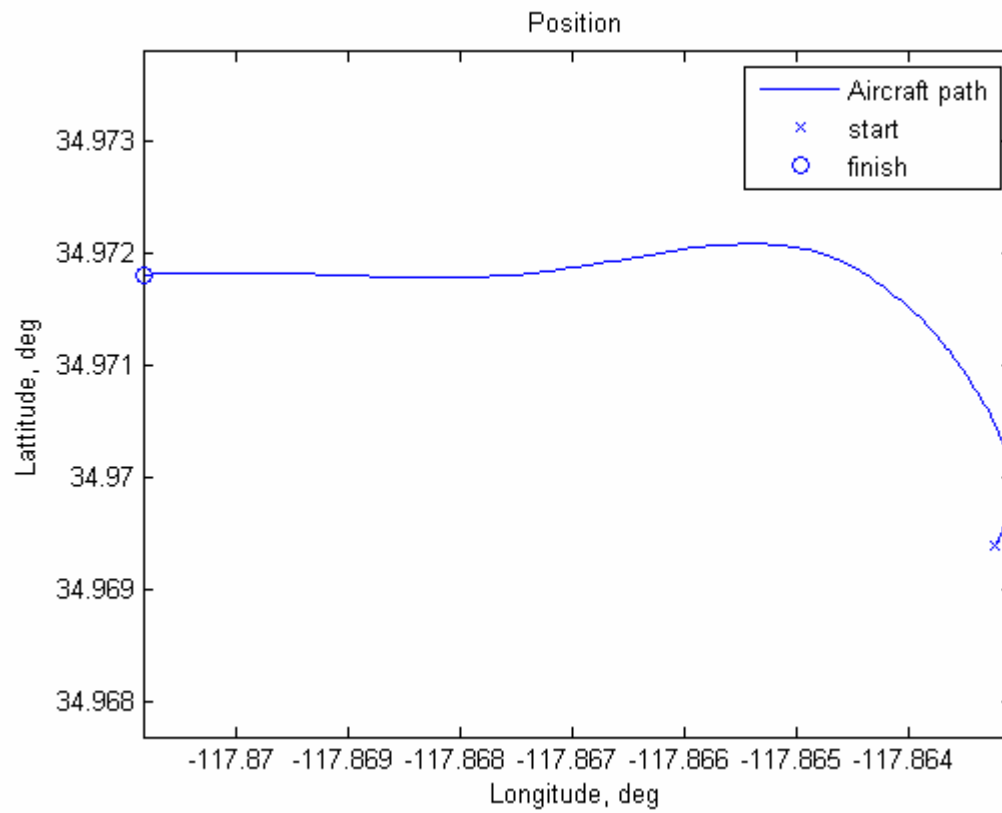


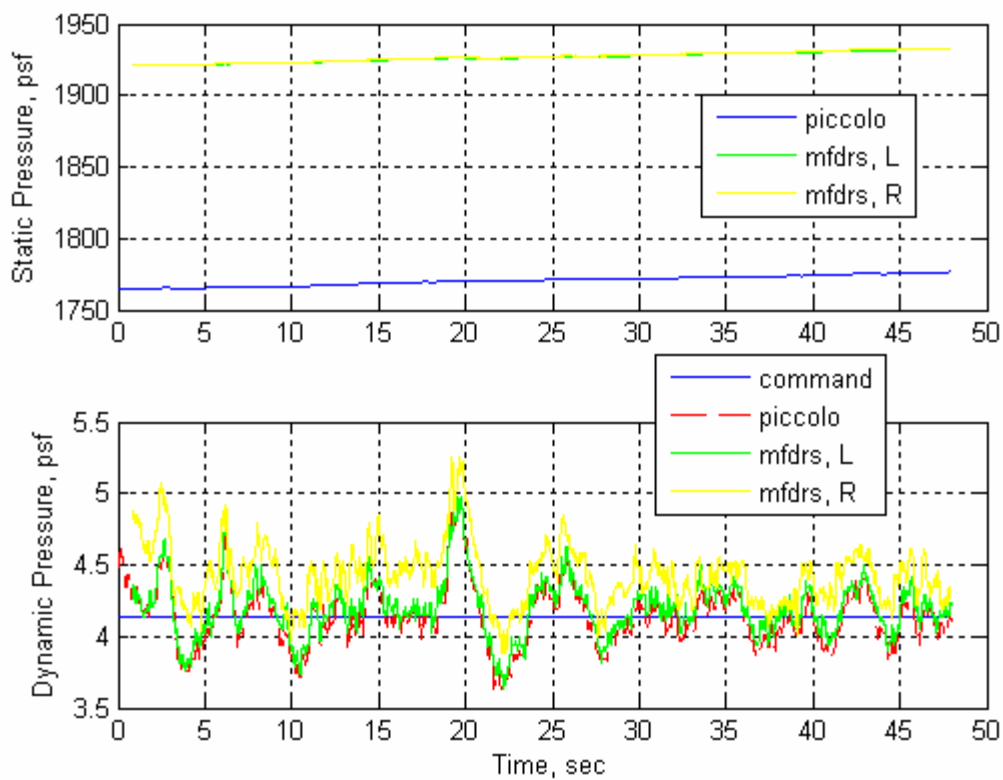
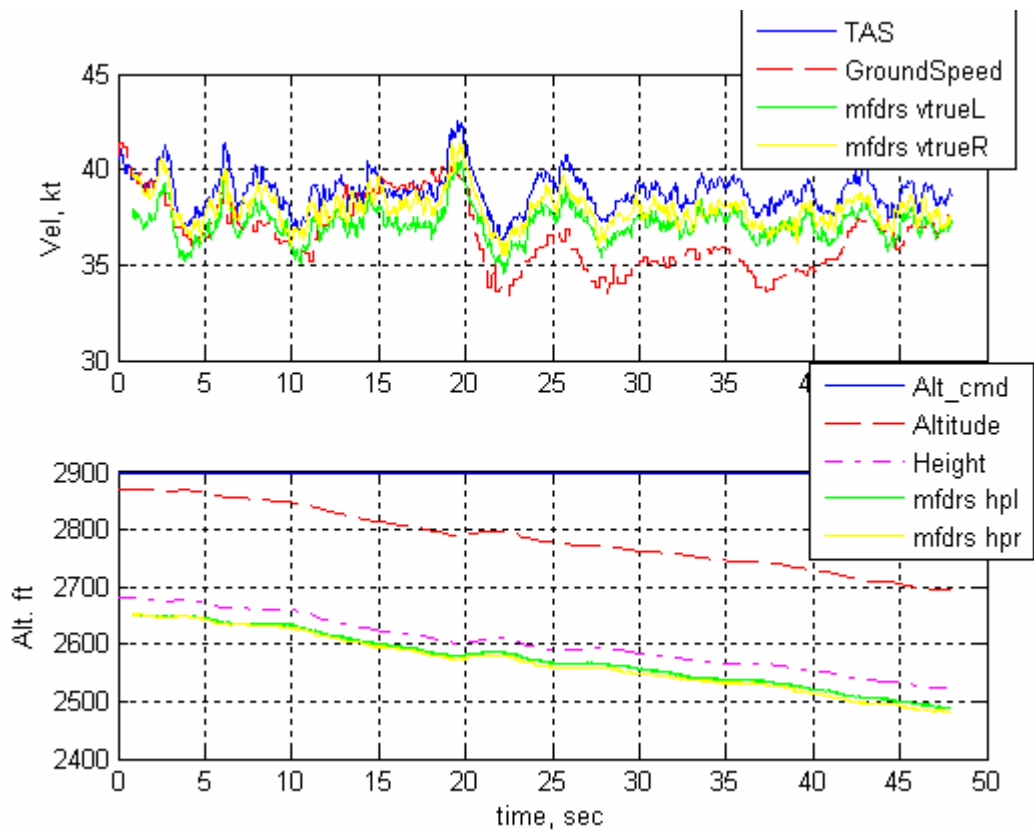


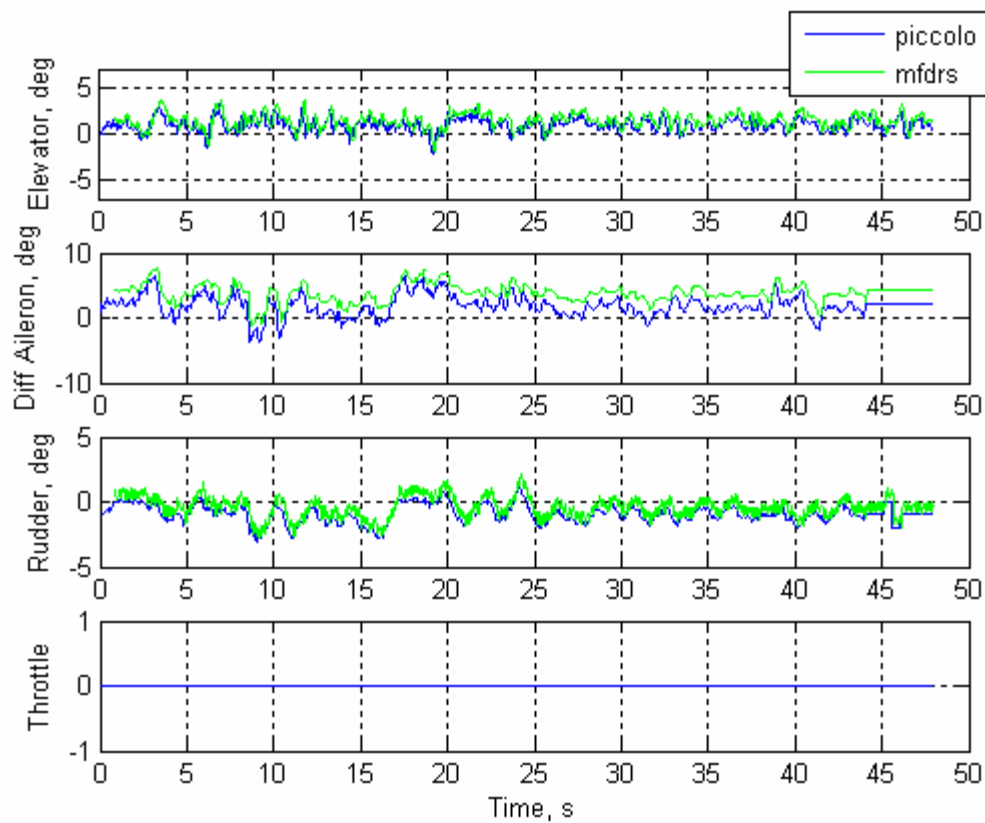
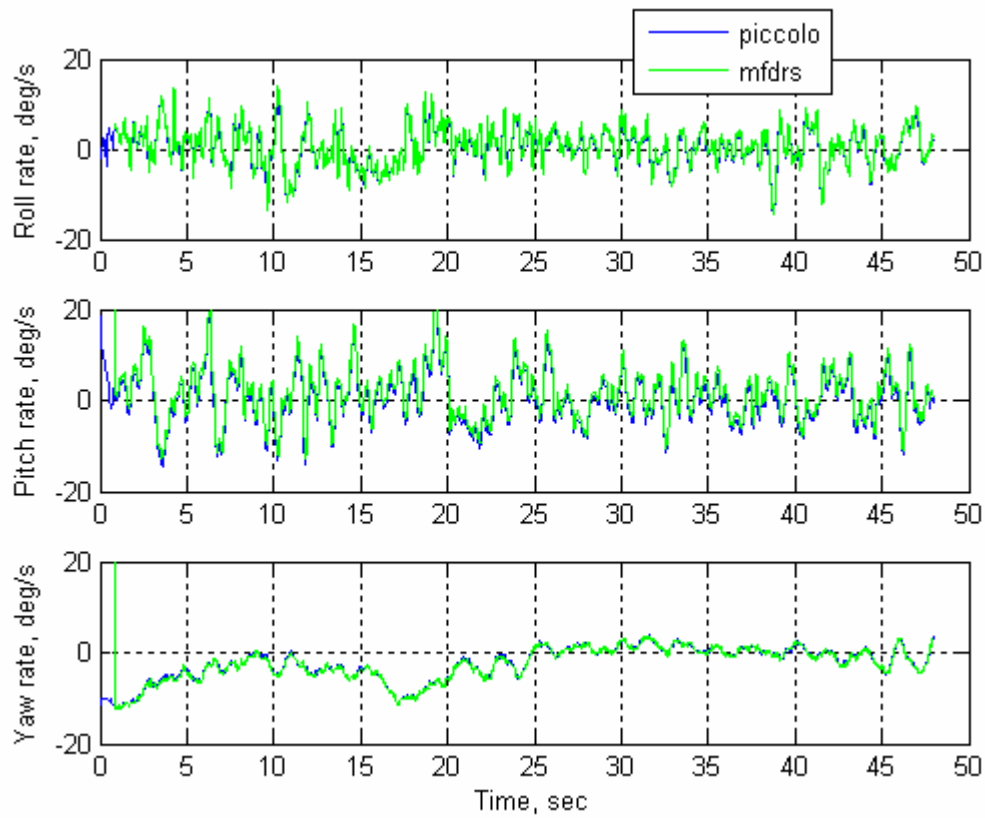


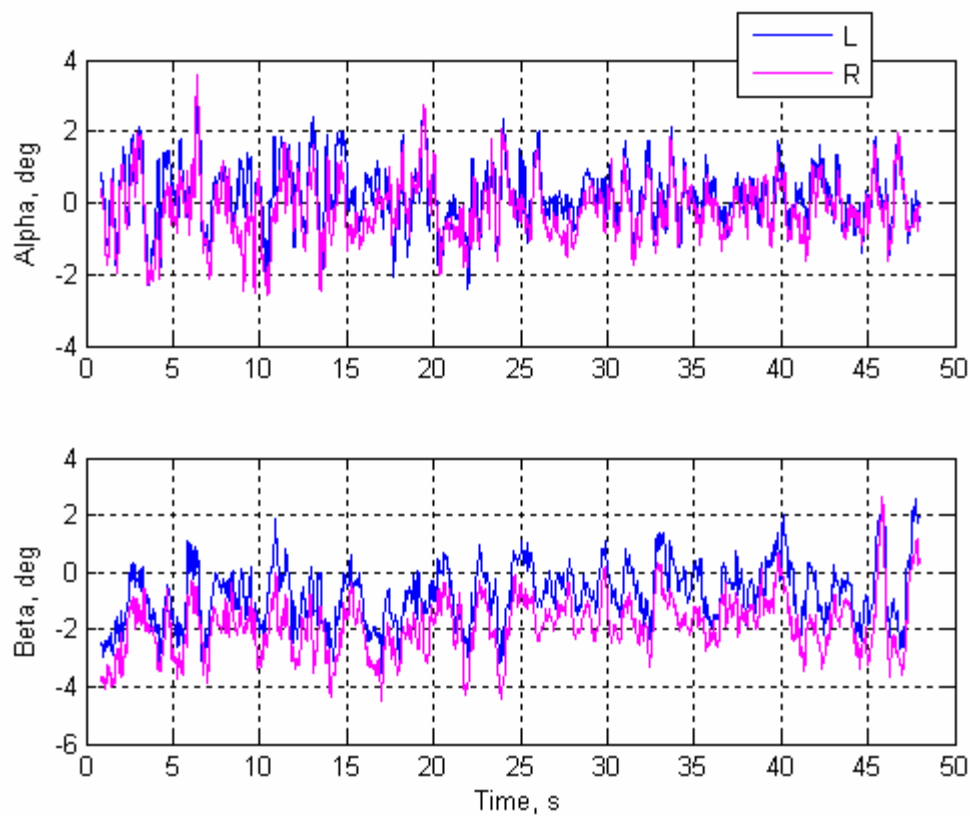
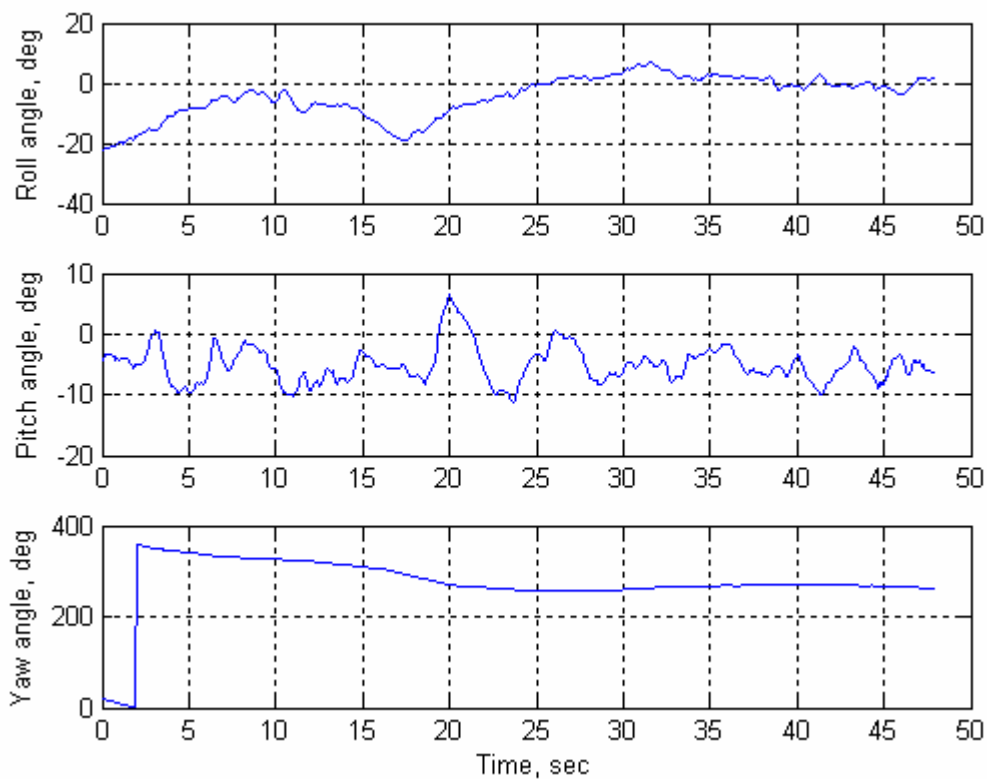
1.6.7 Record 04

This MFDRS file includes a rudder doublet at the end (rudder doublet 2).



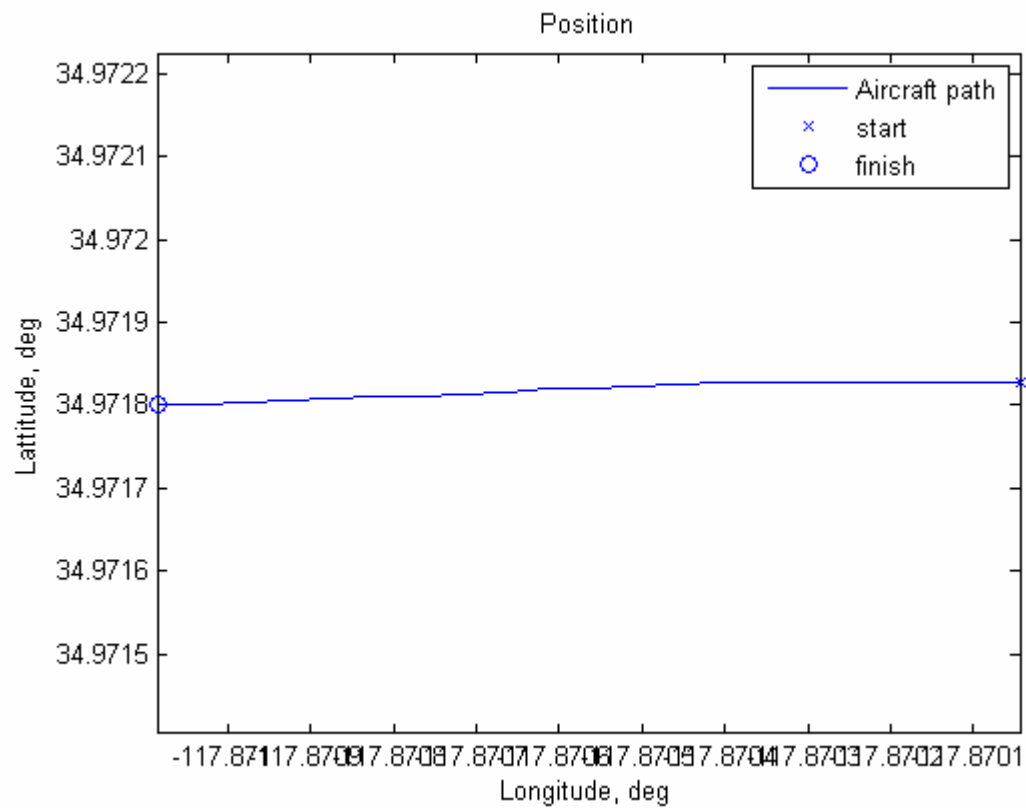


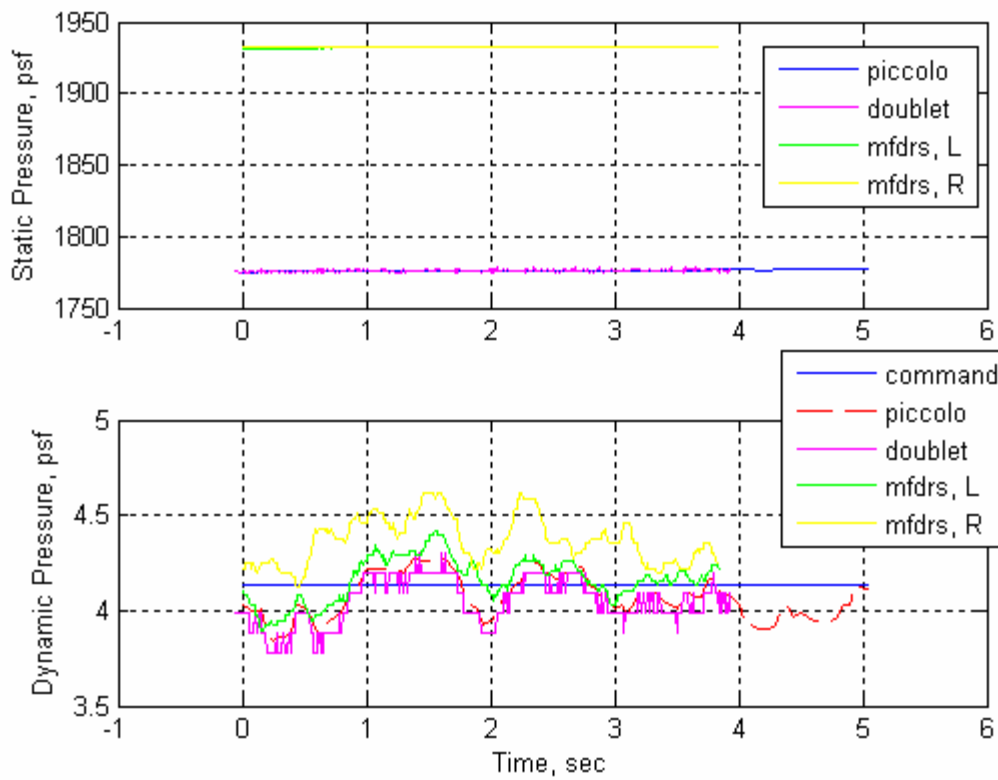
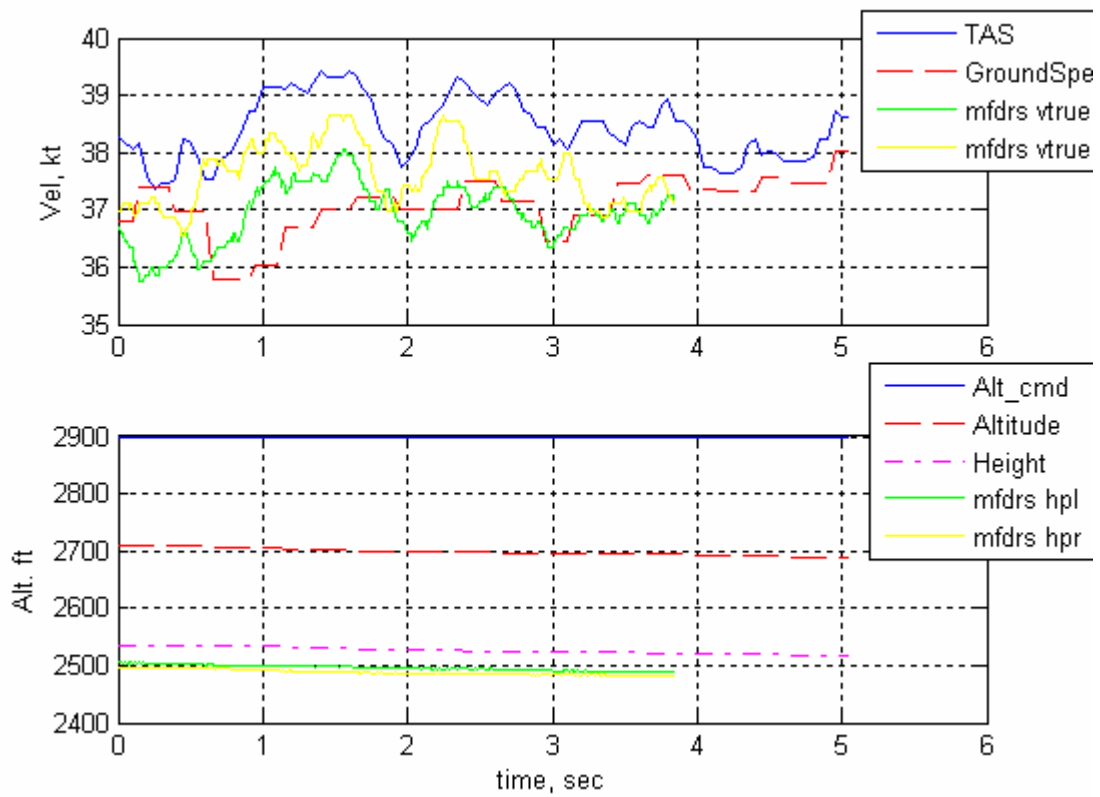


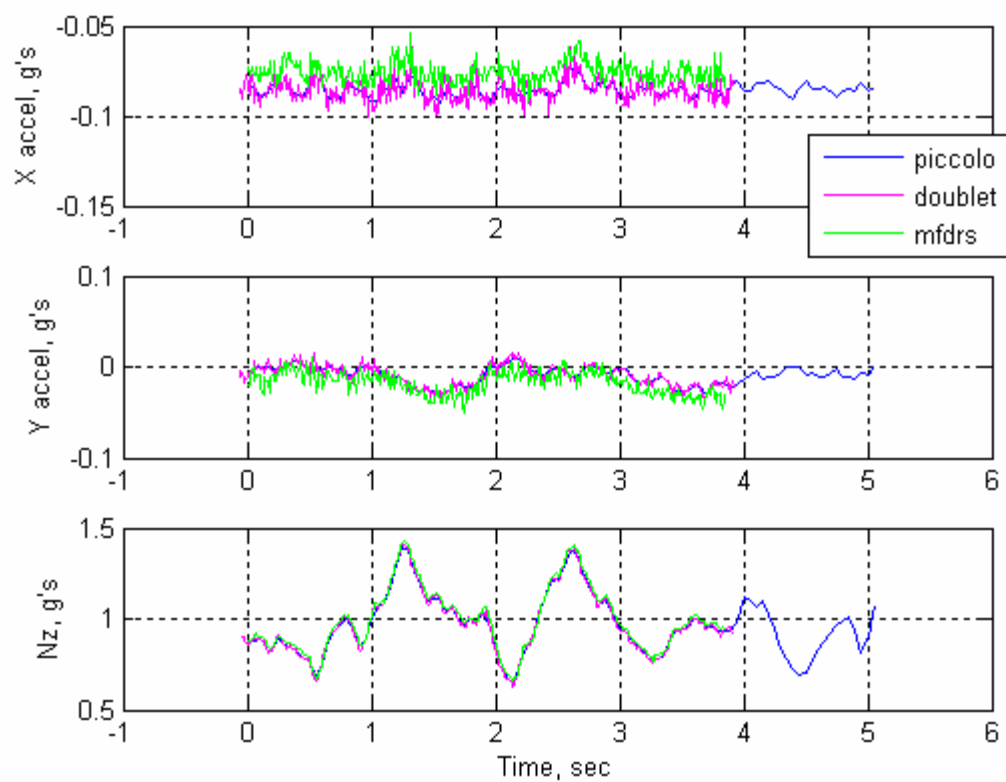
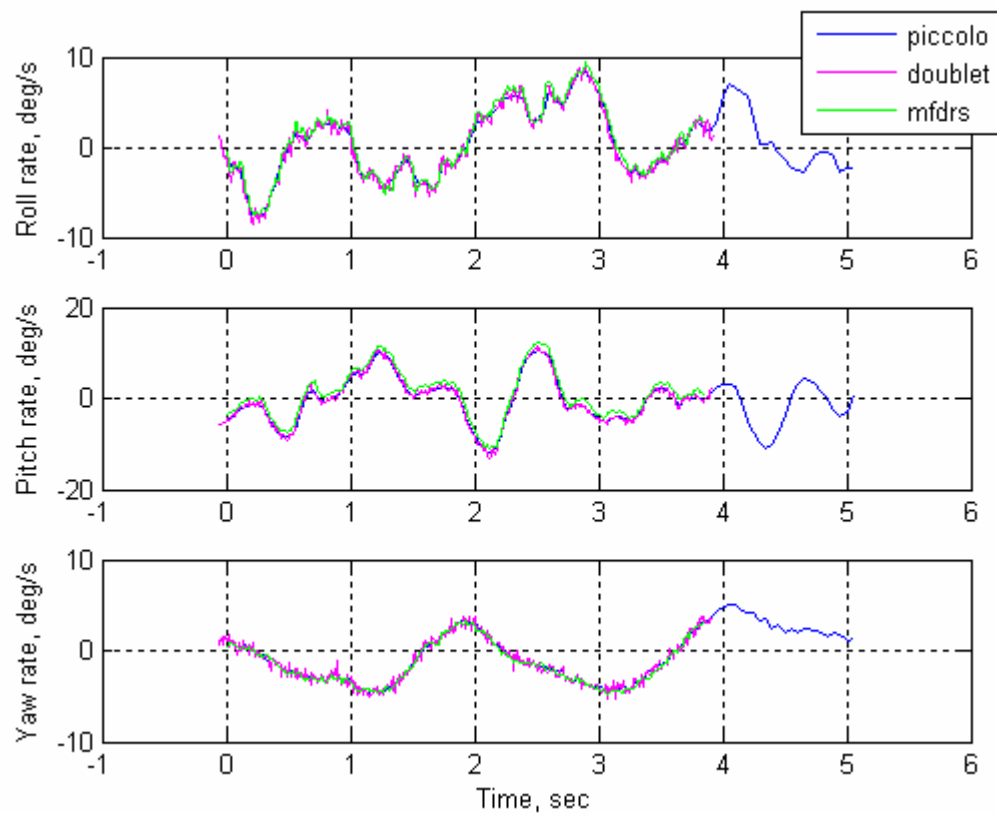


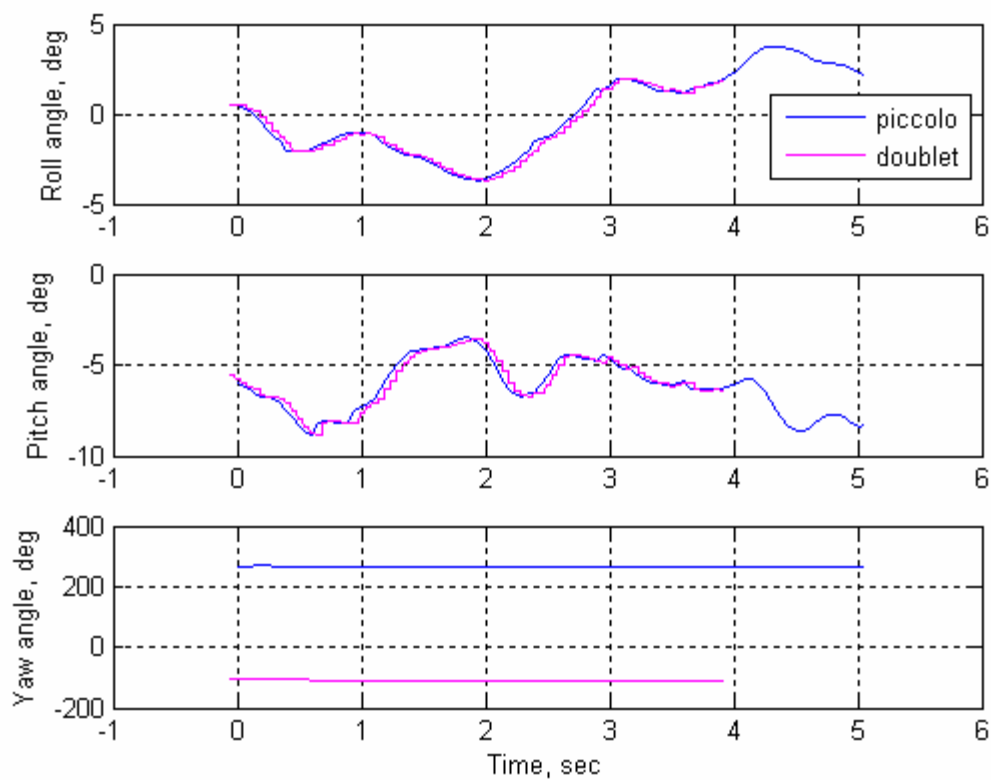
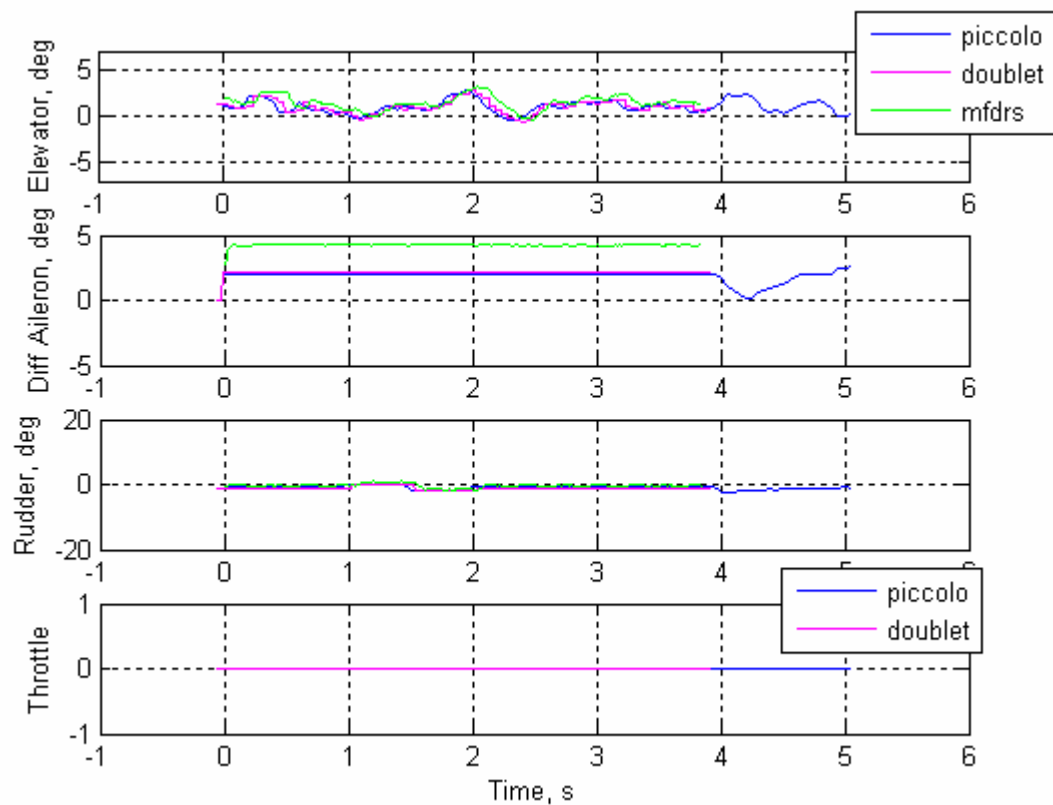
1.6.8 Rudder Doublet

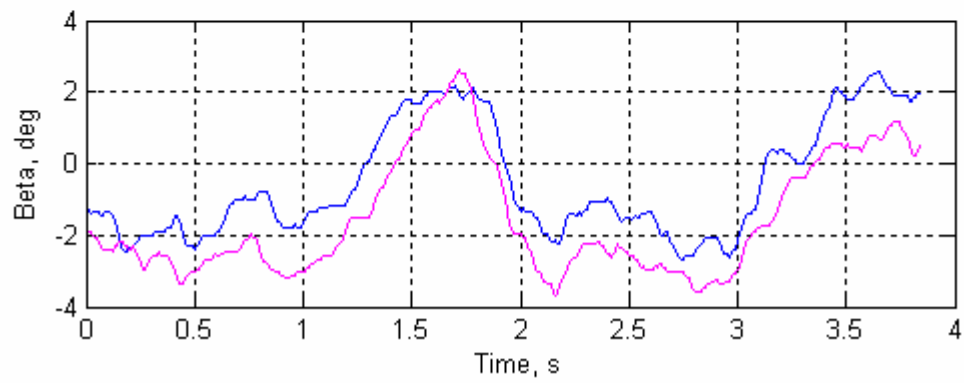
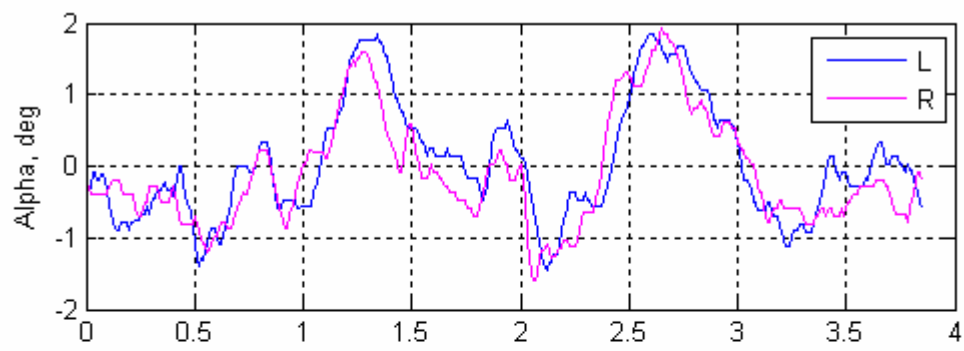
This data is from the MFDRS file RECORD04. Note that the Piccolo and Doublet signals for rudder position and angular rates can not both be aligned at the same time.





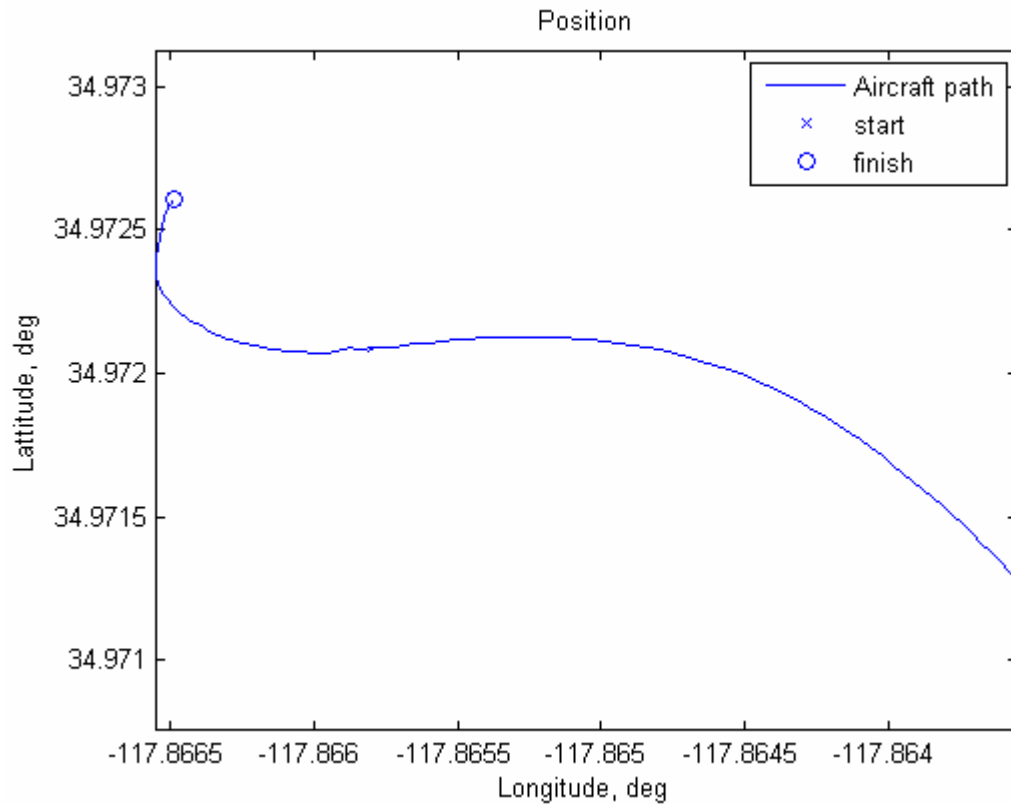


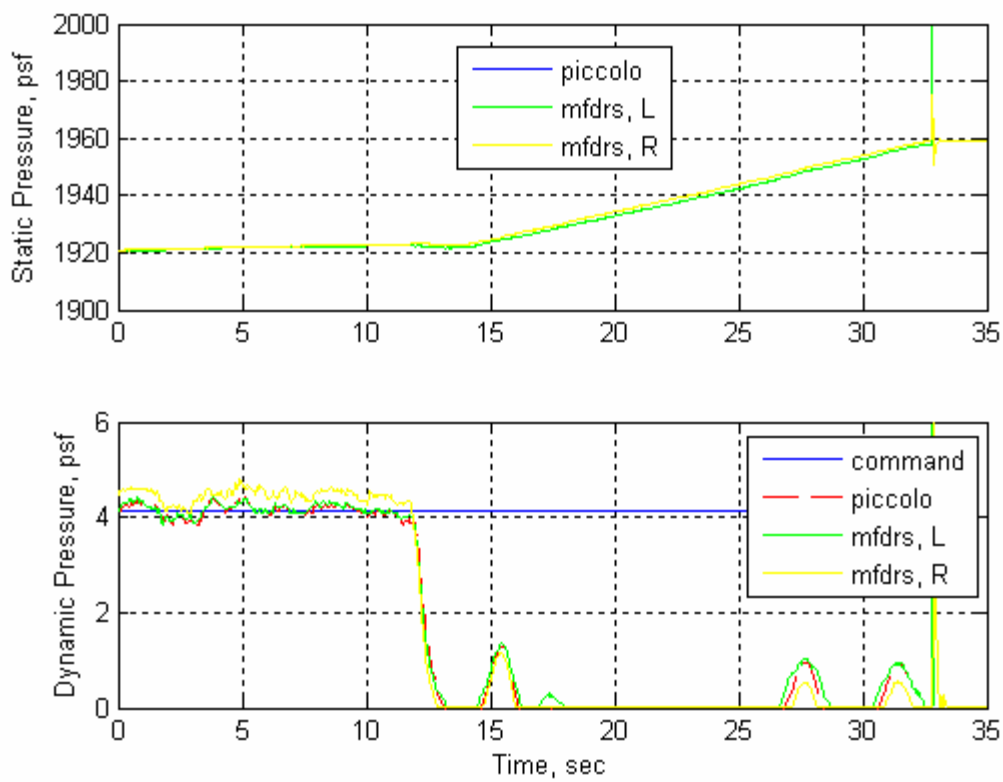
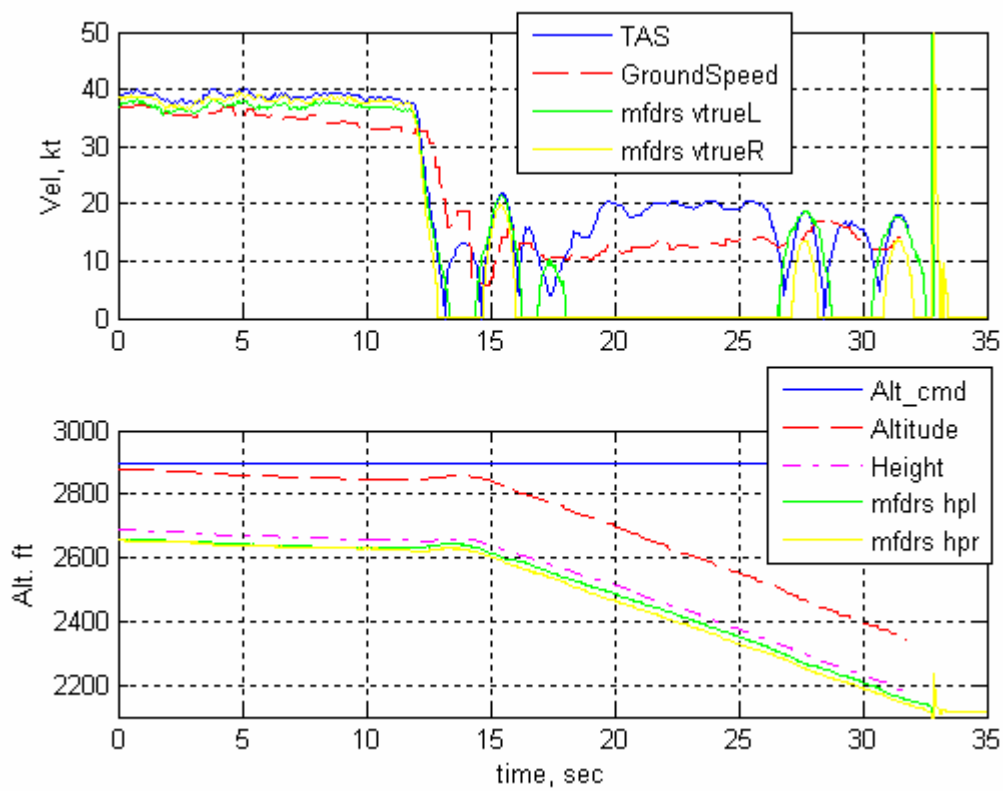


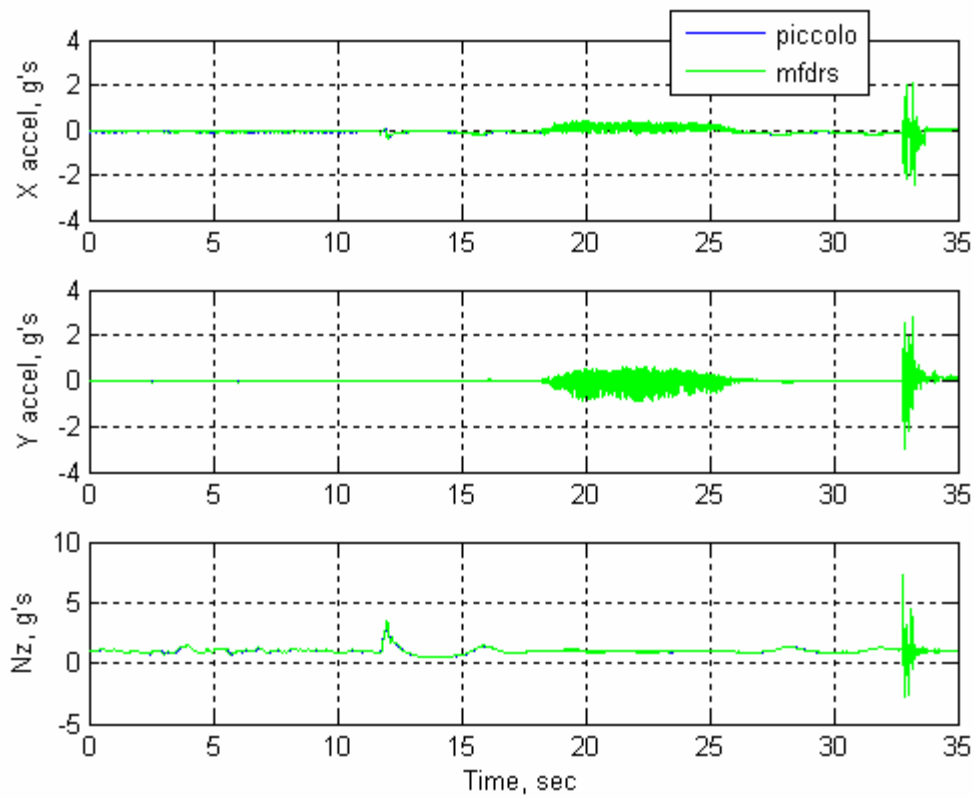
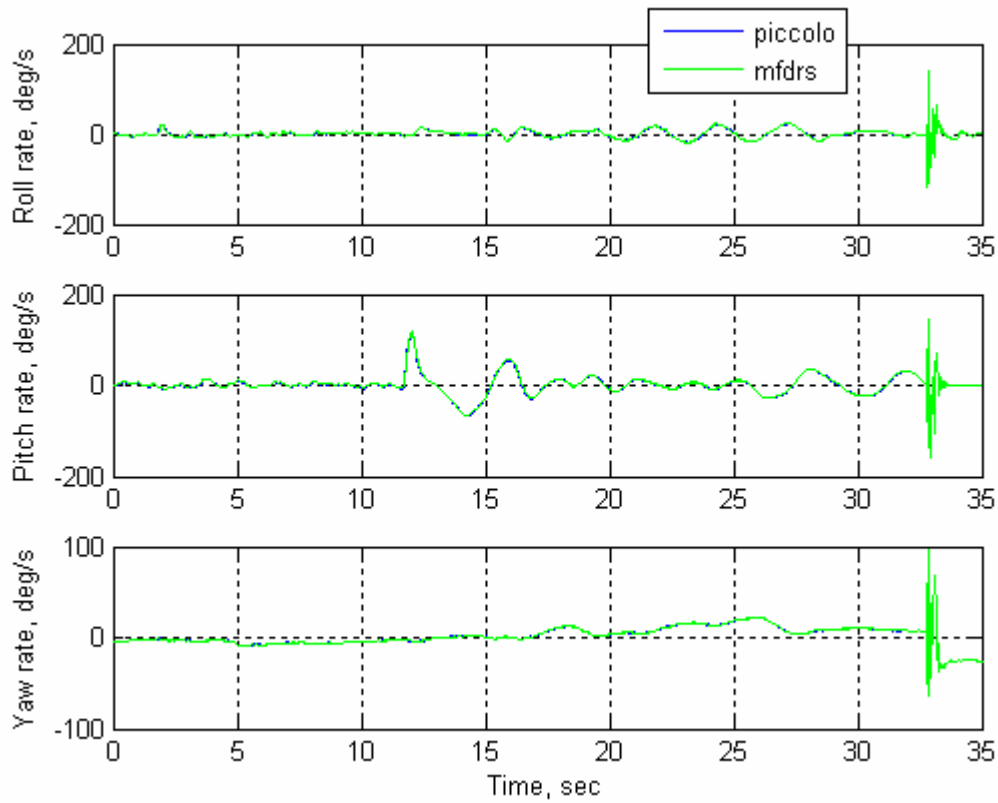


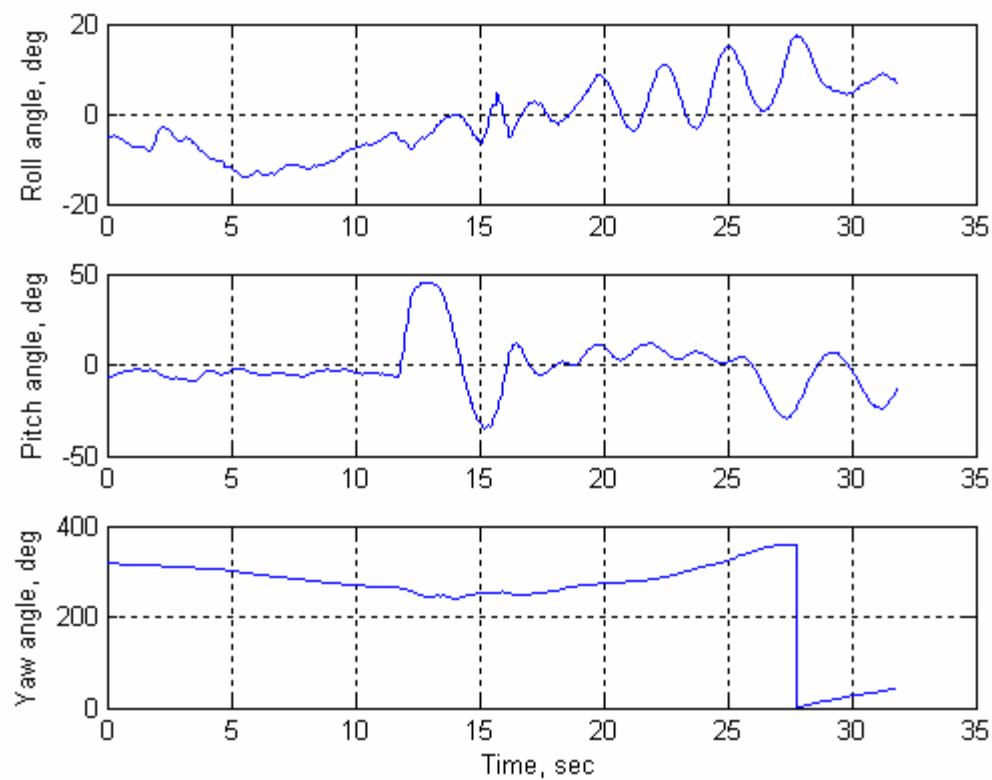
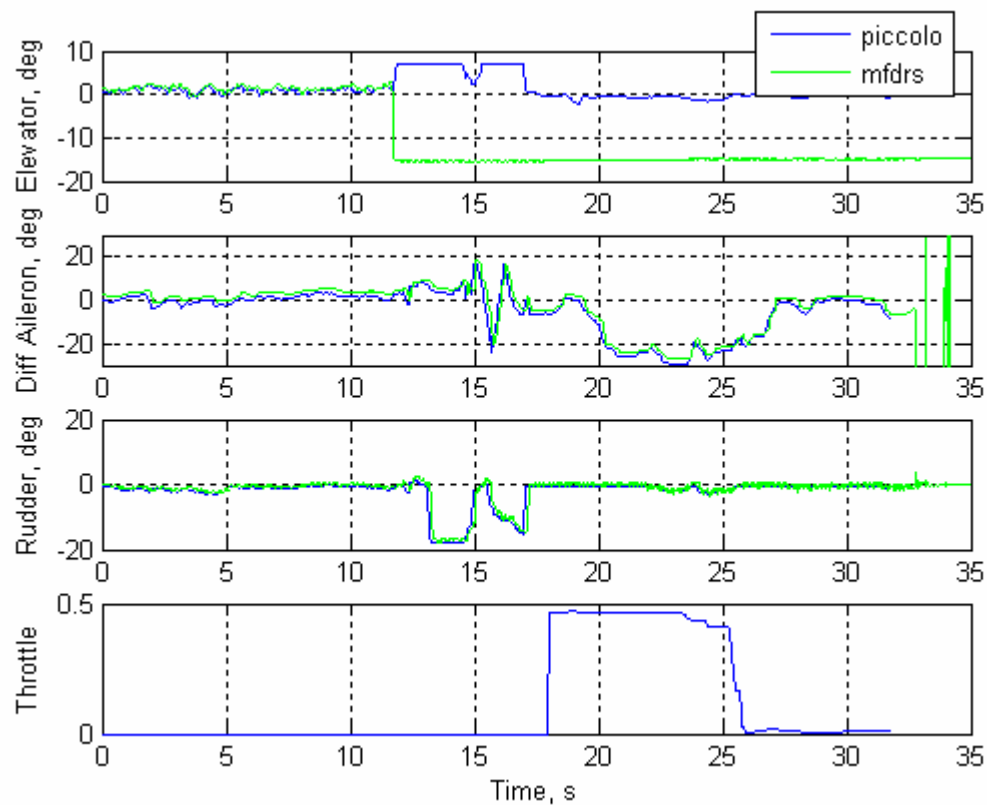
1.6.9 FTS deployment

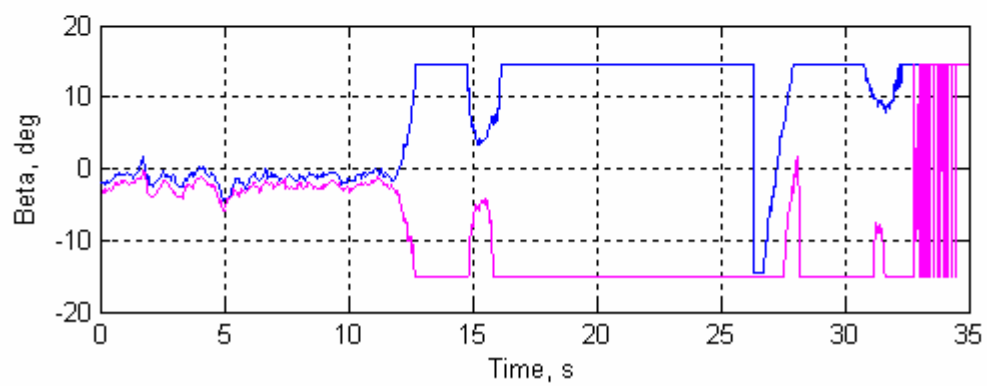
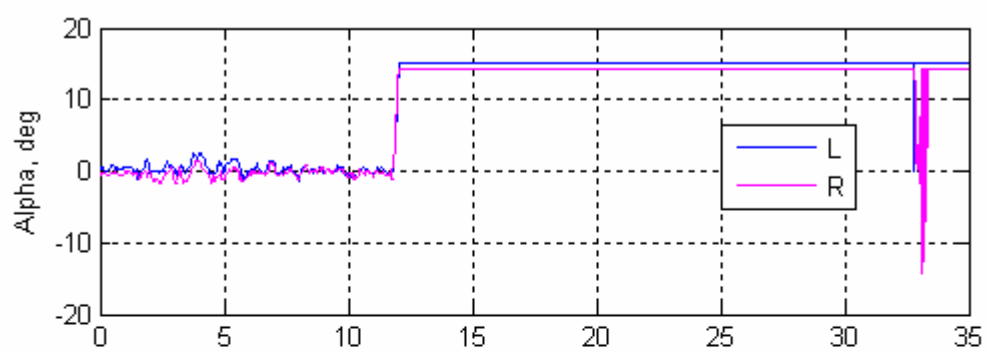
Flight 3 was ended when the aircraft FTS self-deployed. Luckily, the MFDRS was recording during the event. The FTS on this aircraft moves the full-flying horizontal tail to approximately 60deg trailing edge up, causing a deep stall condition. The calibrations for angle of attack, sideslip angle, and elevator position are not valid during the deep stall. The pilot increased the throttle during the descent for a few seconds then returned the throttle to zero











1.6.10 SODAR Data

SODAR Data for flight 3 was taken near the shuttle area, approximately 2 miles away. Sodar data starts at 12/14/2006 23:00:09. Data is reported in 5 minute averages.

